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REPORT ON POLLUTION OF THE NAVIGABLE WATERS OF BOSTON HARBOR

Federal Water Pollution Control Administration
Boston, Massachusetts

May 1968

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REPORT ON POLLUTION OF THE NAVIGABLE WATERS OF

BOSTON HARBOR

NATIONAL TECHNICAL
INFORMATION SERVICE

FEDERAL
WATER POLLUTION CONTROL
ADMINISTRATION

MAY 1968

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United States Department of the Interior
Federal Water Pollution Control Administration
Northeast Region
Boston, Massachusetts

May 1968

TABLE OF CONTENTS

	Page
SUMMARY AND RECOMMENDATIONS	1
SUMMARY	1
RECOMMENDATIONS	5
COMMONWEALTH OF MASSACHUSETTS, WATER QUALITY STANDARDS	8
INTRODUCTION	12
BACKGROUND	12
DESCRIPTION OF AREA	14
POPULATION AND ECONOMY	14
HYDROGRAPHY	16
SOURCES OF POLLUTION	18
MUNICIPAL WASTES	18
INDUSTRIAL WASTES	21
COMBINED SEWER OVERFLOWS	21
TRIBUTARY STREAMS	22
FEDERAL INSTALLATIONS	22
Boston Naval Shipyard	23
South Boston Naval Annex	27
Navy Ships Berthed in Boston Harbor	27
Coast Guard's Base Boston	27
Nike Ajax Site B-36 (Hull)	28
WATERCRAFT WASTES	28
DEBRIS AND REFUSE	28
OTHER SOURCES	29
EFFECTS OF POLLUTION ON WATER USES	30
SHELLFISH HARVESTING	30
Official Control of Shellfish Harvesting	30
Production of Shellfish	35
Economic Value of Shellfish	39
RECREATIONAL BATHING	41
RECREATIONAL BOATING	43
SPORT FISHING	44
ESTHETICS	44
COMMERCIAL SHIPPING	45
WATER SUPPLY	46

TABLE OF CONTENTS (Continued)

	Page
PRESENT WATER QUALITY	47
BACTERIA	47
DISSOLVED OXYGEN	50
BENTHIC LIFE	52
NUTRIENTS	53
BENTHAL DEPOSITS	54
SURFACE WATERS	55
POLLUTION CONTROL AGENCIES	56
STATE AGENCIES	56
Metropolitan District Commission	56
Metropolitan Area Planning Council	56
Division of Water Pollution Control	57
Division of Waterways	57
Department of Public Health	58
FEDERAL AGENCIES	58
Federal Water Pollution Control Administration	58
U.S. Army Corps of Engineers	59
U.S. Coast Guard	59
U.S. Public Health Service	59
OTHER AGENCIES	60
New England River Basins Commission	60
New England Regional Commission	60
APPENDICES	62
APPENDIX A. National Shellfish Sanitation Program, Growing Area Survey and Classification	63
APPENDIX B. Federal Construction Grant Projects, Boston Harbor	75
STUDY AREA .....Follows Page	79

LIST OF FIGURES

Figure		Follows Page
1	Boston Harbor	77
2	Major Wastes Discharges and Average Coliform Densities	18
3	Classification of Shellfish Areas	34
4	Volume of Clams Treated at Newburyport Shellfish Treatment Plant, 1935-1967	38
5	Monthly Volume of Clams Treated at Newburyport Shellfish Treatment Plant, 1967	38
6	Dissolved Oxygen Pattern, Boston Harbor	52
7	Polychaete Worms, Boston Harbor	54
8	Phytoplankton, Boston Harbor	54

LIST OF TABLES

Table		Page
1	Communities Discharging Sewage to the Metropolitan District Commission Sewerage Facilities	19
2	Federal Installations, Boston Harbor	24
3	Shellfish Areas, Boston Harbor	32
4	Master and Subordinate Digger Permits, Northern Massachusetts Coast	36
5	Geographical Distribution of Processed Clams, Newburyport Shellfish Treatment Plant	38
6	Estimated Annual Economic Damage to the Shellfish Industry in Boston Harbor.	42

SUMMARY AND RECOMMENDATIONS

SUMMARY

As a result of pollution of the waters overlying the shellfish growing areas of Boston Harbor, the Commonwealth of Massachusetts has issued orders prohibiting, or otherwise restricting the harvesting of shellfish for human consumption in certain areas in order to protect the public health and welfare. These restrictions, as of April 1, 1968, are summarized below:

Shellfishing prohibited (since 1941)	1,560 Acres	35 percent
Shellfishing prohibited (since June 1967)	1,113	25
Shellfishing restricted	1,319	29
Shellfishing approved	500	11
	4,492 Acres	100 percent

Pollution in the Boston Harbor area results from the following waste discharges and activities:

Municipal Wastes

Metropolitan District Commission's Deer Island sewage treatment plant

Metropolitan District Commission's Nut Island sewage treatment plant

City of Boston's Moon Island facility

Town of Hull

Industrial Wastes

Combined Sewer Overflows

Tributary Streams

Federal Installations

- Boston Naval Shipyard
- Navy Ships Berthed in Boston Harbor
- Coast Guard's Base Boston
- Nike Ajax Site B-36 (Hull)

Watercraft Wastes

Debris and Refuse

The areas of the Harbor in Boston, Hull, Quincy and Weymouth recently closed to shellfish harvesting cover 25 percent of the available shellfishing growing areas. These same areas accounted for 79 percent of the shellfish harvested from the Harbor during the year July 1, 1966 to June 30, 1967, according to records of the Massachusetts Division of Marine Fisheries. This 79 percent, or 7,800 bushels of shellfish, represent a basic shipper market loss of $78,000 a year. In terms of the economic value to the food industry, the maximum annual loss is estimated to be $1,300,000.

In addition to causing the restriction of shellfish harvesting, pollution has resulted in restricted, or otherwise limited, recreational bathing, recreational boating and sport fishing activities and has reduced the esthetic value of the water, beaches and adjoining areas of Boston Harbor.

The predominant factor in restricting the harvesting of shellfish is the presence of coliform bacteria. Although most are harmless in themselves, coliform bacteria are always present in waters polluted by warm-blooded animal wastes and are considered indicators of the probable presence of pathogenic bacteria. During 1967, excessive coliform bacteria, as great as 520,000 per 100 ml of water, were found in the Inner Harbor area. In general, very high numbers were found in the northern section of the Harbor, while Quincy, Hingham and Hull Bays in the southern portion probably satisfy the coliform standards for Massachusetts Class SB waters. Class SB waters are generally considered acceptable for water contact activities and shellfish harvesting with depuration.

Water Quality Standards adopted by Massachusetts require that for Class SB water the dissolved oxygen be "not less than 5 mg/l at any time" and for Class SC water, the lowest classification of salt water, "not less than 5 mg/l during at least 16 hours of any 24-hour period, nor less than 3 mg/l at any time." Of the eighteen stations sampled during July and August of 1967, only six met this Class SC standard.

Wide fluctuations of dissolved oxygen values occurred in Boston Harbor, apparently caused by large numbers of phytoplankton. Such fluctuations, with resulting serious oxygen depletions, are often caused by rapidly expanding phytoplankton populations in waters having very high nutrient concentrations.

The paucity of kinds of organisms associated with the benthic deposits, show that all reaches of Boston Harbor and each of its tributary streams, except the inland marine reaches of the Weir and Weymouth Back Rivers, were polluted. Based upon the biological conditions about seven square miles, or 30 percent of the Harbor, were grossly polluted. Chemical analysis of harbor sediments for carbon and nitrogen support the biological findings of organic enrichment. Extensive deposits, some greater than three feet deep, of decaying organic matter and incorporated oily residues covered much of the Harbor.

Substantial economic injury results from the inability to market shellfish or shellfish products in interstate commerce because of pollution caused by sewage, industrial waste and other waste sources discharged to the navigable waters of Boston Harbor and its tributaries, and by the action of State authorities. Accordingly, the pollution of those navigable waters is subject to abatement under procedures described in Section 10 of the Federal Water Pollution Control Act, as amended.

RECOMMENDATIONS

The following are recommendations for abating the existing water pollution and for ensuring the adequate water quality required for legitimate water uses, including shellfish harvesting, of Boston Harbor. These recommendations are designed for the present conditions. Any basic alteration in the harbor's condition, either natural or caused by man, may necessitate a review of the requirements.

1. All waters in Boston Harbor shall meet the water quality standards, including the implementation and construction schedules, submitted by the Commonwealth of Massachusetts and approved by the Secretary of the Interior. These standards are at the end of this recommendations section.
2. a. The Deer Island sewage treatment facility shall be fully staffed and operation continued.
   b. A technical committee shall be established to determine if the standards of water quality are being met. The committee shall report its findings to the conferees in six months.
   c. An evaluation of the effect of the treated discharges of both the Deer Island and Nut Island facilities on the harbor waters shall be completed as soon as possible. If needed, a survey should be undertaken to determine what additional pollution abatement measures are necessary.

d. The evaluations and studies shall also consider the need for discharging all wastes, including dry weather flows and combined sewer overflows, to waters other than those of Boston Harbor.

e. A proposed plan to accomplish any additional measures shall be reported to the conferees by June 1969.

3. a. The City of Boston shall formulate and implement the complete phasing out of the Moon Island facility.

b. As an interim measure, continuous disinfection of all discharges from Moon Island, in accordance with orders established by the Massachusetts Division of Water Pollution Control, shall be provided.

4. a. Appropriate local, State and Federal agencies shall adequately control the dumping of garbage or refuse along the shores and in the waters of the harbor.

b. Material in existing dump sites, sunken vessels, dilapidated piers, wharves and other structures, and other sources and sites of debris and rubbish, shall be removed and the appearance of the bank restored to an esthetically acceptable condition.

5. The problem of pollution from vessels in Boston Harbor is serious. A technical committee, including State and Federal representatives, shall be established to consider the vessel pollution problem and provide the conferees with recommendations in six months.

6. Industry and local, State and Federal agencies shall complete and implement contingency plans for the most appropriate and effective methods of preventing and handling oil pollution.

7. All municipalities, industries and the Metropolitan District Commission shall continue immediate remedial action, including repair or replacement, as needed, of all storm overflow structures and tide gates to eliminate backflow from the harbor and its tributaries into the sewerage system.

8. All Federal facilities shall construct and operate treatment facilities required by Executive Order 11288.

COMMONWEALTH OF MASSACHUSETTS

WATER QUALITY STANDARDS

Division of Water Pollution Control acting under the authority of Section 27 (4) of Chapter 21 of the General Laws held a public hearing on February 17, 1967, relative to the establishment of standards of water quality for the waters of the Commonwealth. The hearings were held in accordance with the provisions of the State Administrative Procedures Act (Chapter 30A of the General Laws). The standards were approved by the Water Resources Commission, the Commissioner of Public Health, and adopted by the Division on March 3, 1967, and were filed with the Secretary of State on March 6, 1967. The standards were approved by the Secretary of the Interior on August 10, 1967.

1. General - To achieve the objectives of the Massachusetts Clean Water Act and to assure best use of the waters of the Commonwealth, the following standards are adopted and shall be applicable to all waters of the Commonwealth or to different segments of the same waters. The Classes shall be assigned by the Division of Water Pollution Control.

In the classification of waters due consideration will be given to all factors involved including public health, public enjoyment, propagation and protection of fish and wildlife, and economic and social development. Classifications are not intended to permit indiscriminate waste disposal or to allow minimum efforts of waste treatment under any circumstance.

When an effluent is permitted to be discharged to the receiving waters, cognizance shall be given both in time and distance to allow for mixing of effluent and stream. Such distances required for complete mixing shall not affect the water usage Class adopted.

Recommendations on other waste parameters will constitute a portion of the continuing effort of the Division as improved standard methods are developed or revisions consistent with the enhancement of the waters of the Commonwealth are justified.

Water quality parameters not specifically denoted shall not exceed the recommended limits on the most sensitive and governing water class use. In areas where fisheries are the governing consideration and approved limits have not been established, bio-assays shall be performed as required by the appropriate agencies.

MASSACHUSETTS

Coastal and Marine Water Standards of Quality

	Class SA - Suitable for any high quality water use including bathing and water contact sports. Suitable for approved shellfish areas.	Class SB - Suitable for bathing and recreational purposes including water contact sports; industrial cooling; excellent fish habitat; good aesthetic value and suitable for certain shellfisheries with depuration. (Restricted Shellfish Areas).	Class SC - Suitable for aesthetic enjoyment; for recreational boating; habitat for wildlife and common food and game fishes indigenous to the region; industrial cooling and process uses.
1. Dissolved Oxygen	Not less than 6.5 mg/l at any time.	Not less than 5.0 mg/l at any time.	Not less than 5 mg/l during at least 16 hours of any 24-hour period nor less than 3 mg/l at any time.
2. Sludge deposits-solid refuse-floating solids-oil-grease-scum	None allowable	None allowable	None except that amount that may result from the discharge from a waste treatment facility providing appropriate treatment.
3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this class.		
4. Coliform bacteria per 100 ml	Not to exceed a median value of 70 and not more than 10% of the samples shall ordinarily exceed 230 during any monthly sampling period.	Not to exceed a median value of 700 and not more than 2300 in more than 10% of the samples during any monthly sampling period.	None in such concentrations that would impair any usages specifically assigned to this class.
5. Taste and odor	None allowable	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish or shellfish.	
6. pH	6.8 - 8.5	6.8 - 8.5	6.5 - 8.5
7. Allowable temperature increase	None except where the increase will not exceed the recommended limits on the most sensitive water use.		
8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the water for any other usage.		
9. Radioactivity	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the appropriate water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.		
10. Total phosphate	Not to exceed an average of 0.07 mg/l as P during any monthly sampling period.		
11. Ammonia	Not to exceed an average of 0.2 mg/l as N during any monthly sampling period.	Not to exceed an average of 0.2 mg/l as N during any monthly sampling period.	Not to exceed an average of 1.0 mg/l as N during any monthly sampling period.

NOTES:

1. Coastal and marine waters are those subject to the rise and fall of the tide.
2. Appropriate treatment is defined as the degree of treatment with disinfection required for the receiving waters to meet their assigned state or interstate classification and to meet the objectives of the water quality standards. Disinfection from October 1 to May 1 may be discontinued at the discretion of the Division of Water Pollution Control.
3. The water quality standards do not apply to conditions brought about by natural causes.
4. The waters shall be substantially free of pollutants that will:
   (1) unduly affect the composition of bottom fauna
   (2) unduly affect the physical or chemical nature of the bottom fauna
   (3) interfere with the spawning of fish or their eggs
5. The standards shall apply at all times in coastal and marine waters
6. The amount of disinfection required shall be equivalent to a free and combined chlorine residual of at least 1.0 mg/l after 15 minutes contact time during peak hourly flow or maximum rate of pumpage.

Water Resources Commission
Division of Water Pollution Control

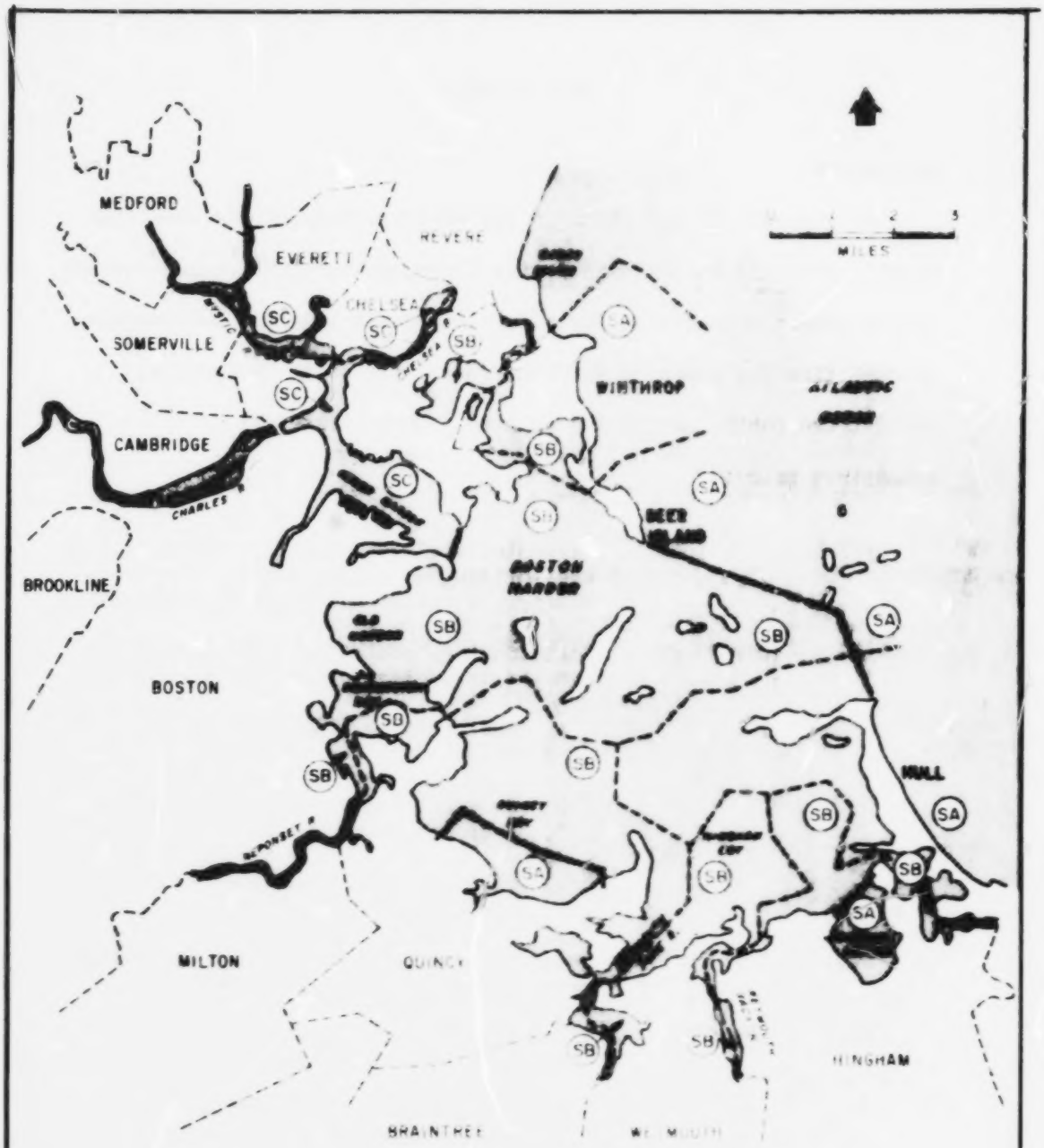
BOSTON HARBOR WATERS CLASSIFICATION*

BOUNDARY	PRESENT AND ANTICIPATED FUTURE USE	CLASSIFICATION PRESENT	CLASSIFICATION FUTURE
Boston Harbor inside a line from the southerly tip of Deer Island to Boston Light House to Point Allerton in Hull except as noted below	Bathing Recreational boating Fish and wildlife propagation Fishing Shellfishing Assimilation	SC	SB
Boston Inner Harbor westerly inside a line from the southerly tip of Governor's Island to Port Independence including the Charles, Mystic and Chelsea (Creek) Rivers and Port Point Channel	Fish and wildlife propagation Fishing Industrial Processing and Cooling	SC	SC
Quincy Bay in Quincy from Bromfield Street near the Wollaston Yacht Club northerly to buoy C "1" southeasterly to the "Willows" sometimes known as Lord's Point on the northerly shore of Houghs Neck in Quincy	Bathing Recreational boating Fish and wildlife propagation Fishing Shellfishing	SA	SA
Hingham Harbor in Hingham inside a line from Crows Point to World's End Promontory	Bathing Recreational boating Fish and wildlife propagation Fishing Shellfishing	SA	SA
Weymouth Fore River in Quincy and Weymouth	Recreational boating Fish and wildlife propagation Fishing Shellfishing, industrial processing and cooling	SB	SB
Weymouth Back River in Weymouth and Hingham	Recreational boating Fish and wildlife propagation Fishing Shellfishing Industrial processing and Cooling	SB	SB
Weir River in Hull and Hingham	Bathing Recreational boating Fish and wildlife propagation Fishing Shellfishing Industrial cooling and Processing	SB	SB
Neponset River in Boston, Milton and Quincy	Recreational boating Fish and wildlife propagation Fishing Shellfishing Industrial cooling and Processing	SB	SB

*Subject to the rise and fall of the tide

LOCATION	SOURCE	TYPE OF WASTE	COASTAL WATER CLASSIFICATION PRESENT	COASTAL WATER CLASSIFICATION PROPOSED	TREATMENT PRESENT	TREATMENT REQUIRED
Boston	MDC Deer Island	Sanitary (C)	SB	SB	Primary	Adequate
	MDC Nut Island	Sanitary (C)	SB	SB	Primary	Adequate
Hull	Municipal	Sanitary	SB	SA	None	Primary*

(C) Combined sewers
*To be completed by March 1972



COMMONWEALTH OF MASSACHUSETTS
WATER RESOURCES COMMISSION

BOSTON HARBOR
CLASSIFICATION

WATER USE CLASSES - (SA) (SB) (SC)
— CHANGE CLASSIFICATION

INTRODUCTION

BACKGROUND

As a result of pollution of the waters overlying the shellfish growing areas in Boston Harbor, the Commonwealth of Massachusetts has issued orders prohibiting, or otherwise restricting the harvesting of shellfish for human consumption in certain areas in order to protect the public health and welfare. These restrictions are summarized below:

February 13, 1937 - Harvested shellfish from the Slate Island area of Hingham and Weymouth must receive appropriate treatment prior to consumption.

May 5, 1941 - Shellfishing prohibited in Boston Harbor, except for designated areas. As a result,

a. Shellfishing is prohibited in approximately 1,560 acres,

b. Shellfishing is restricted in approximately 2,432 acres, and

c. Shellfishing is unrestricted in approximately 500 acres.

June 1, 1967 - Shellfishing prohibited in the Old Harbor area. First closure since 1941.

April 1, 1968 - Since June 1, 1967, 1,113 additional acres have been prohibited. As a result,

a. Shellfishing is prohibited in approximately 2,673 acres,

b. Shellfishing is restricted in approximately 1,319 acres, and

c. Shellfishing is unrestricted in approximately 500 acres.

The only unrestricted or open areas are located along the southern shores of the Harbor. These areas are under observation by the Massachusetts Department of Public Health to determine whether or not they should also be restricted.

As provided in the Federal Water Pollution Control Act, as amended,

> "The Secretary shall also call such a conference whenever, on the basis of reports, surveys, or studies,... he finds that substantial economic injury results from the inability to market shellfish or shellfish products in interstate commerce because of pollution..." "... and action of Federal, State, or local authorities."

The Secretary of the Interior has called a conference of the navigable waters of Boston Harbor.

Numerous personnel from the following agencies assisted in the collection of data or report preparation: United States Department of Health, Education, and Welfare, Public Health Service; United States Army, Corps of Engineers; Massachusetts Department of Public Health, Division of Sanitary Engineering; Massachusetts Department of Natural Resources, Division of Marine Fisheries, and Division of Water Pollution Control; Massachusetts Department of Commerce, Metropolitan Area Planning Council, Boston; and Metropolitan District Commission, Sewerage Division. The cooperation of all is gratefully acknowledged.

DESCRIPTION OF AREA

The area, as defined by the Massachusetts Department of Public Health for shellfishing purposes, is "...the waters and flats of Boston Harbor, including all its arms and tributaries, west of a line drawn from Windmill Point in Hull to the southeasterly point of Deer Island...to Point Shirley and including the shores of Lovells, Gallops and Georges Islands..." and is shown in Figure 1. These areas have been defined and established as shellfish grounds as far back as 1937 and have been periodically reevaluated. This area, known as Boston Harbor, includes Boston Inner Harbor, Boston Outer Harbor, Winthrop Harbor, Dorchester Bay, Quincy Bay, Hingham Bay and Hull Bay. It has a surface area of approximately twenty-four square miles.

Boston Harbor receives the drainage, including waste discharges, from four major coastal streams--the Mystic, Charles, Neponset and Weymouth Fore Rivers; the entire waterfront and minor tributary areas extending from Winthrop to Hull; and all of the municipalities which are part of the Metropolitan District Commission sewerage system. This area, containing 664 square miles and supporting a population of approximately 2 million, lies completely within the Commonwealth of Massachusetts. It contains forty-eight cities and towns in their entirety and significant portions of eleven others.

POPULATION AND ECONOMY

In 1965 the total population of the Boston Standard Metropolitan Statistical Area (SMSA) was 2,600,000, one-half of the state population

and one-quarter of the population of New England. Although the core city of Boston declined in population from 725,000 in 1955 to 620,000 in 1965, the population of the SMSA increased 6.1 percent. The population of Massachusetts had a slightly higher percent increase in the same period, 7.4 percent. Within New England, the Boston area's role as the cultural, commercial, industrial and financial leader is unchallenged.

Employment in the area is growing at a slightly faster rate than in the state as a whole. Total employment in Massachusetts advanced 9.5 percent between 1950 and 1960, while employment in the Boston metropolitan area increased 12 percent.

Compared to the rest of the state, the employment pattern in this area is centered somewhat less on manufacturing and more on service industries, particularly insurance, education, medical services and government. Of those employed in the state, 53 percent and 35 percent are engaged in service and manufacturing activities, respectively. In the Boston SMSA, 63 percent and 29 percent of those employed are engaged in service and manufacturing activities. Manufacturing employment is concentrated mainly in electrical machinery, apparel, and food and kindred products.

The Port of Boston, with an annual total volume of over twenty million short tons of cargo, is the largest seaport in New England, both in its extent of waterfront facilities and in its volumes of waterborne trade. Boston ranks as the fourth largest seaport in the North Atlantic

area after New York, Baltimore and Philadelphia. In the last decade, the Port of Boston has increased in cargo and passenger transport, but its growth has lagged in relation to other North Atlantic ports.

HYDROGRAPHY

Boston Harbor, which opens to Massachusetts Bay, is approximately twenty-four square miles in area. More than three-quarters of the harbor has a mean low water (MLW) depth of ten feet or less. Two major shipping channels serve Boston Harbor; President Roads, with an MLW depth of forty feet, and Nantasket Roads, with an MLW depth of thirty feet. There are approximately one and a half miles of effective harbor connections with Massachusetts Bay.

The maximum current velocity in the main channels is 2.0 knots, occurring near Deer Island Light three hours after the beginning of flood tide. In terms of flow and circulation, the harbor may be divided into sections. The northern section is comprised of President Roads, Dorchester Bay and Inner Harbor; the southern section is comprised of Quincy Bay, Hingham Bay and Hull Bay. In both sections the tidal fluctuation is approximately nine and a half feet.

On a volume-flow relationship, the residence time is slightly under two complete tidal cycles--approximately twenty-four hours. However, the harbor is not completely flushed out every twenty-four hours, for there are many sections where backwaters and poor circulation result in much greater residence times.

The total flow from the tributary streams ranges from 20 cfs to 1,800 cfs, averaging 350 cfs during the summer. This flow is very low compared to the daily inflow of salt water, which averages 320,000 cfs for a six-hour period.

Annual precipitation for the area averages forty-three inches. Approximately sixty-five percent of this precipitation occurs in the winter and spring.

SOURCES OF POLLUTION

Boston Harbor receives the discharge of municipal wastes from 1.5 million people served by the Metropolitan District Commission (MDC) sewerage system and municipal wastes from parts of Hull and Boston. Degradation of water quality in the harbor also results from industrial waste discharges; combined sewer overflows; streams tributary to the harbor; Federal facilities discharges; watercraft wastes; debris and refuse contributed by barging operations, shoreline refuse dumping and dilapidated piers and wharves; and other sources.

MUNICIPAL WASTES

The greatest source of pollution to the waters of Boston Harbor is the discharge of municipal wastes. Approximately 460 million gallons per day (mgd) of raw or partially treated sewage from the Boston metropolitan area are discharged through two major sewerage systems operated by the MDC.

The South Metropolitan system serves twenty-two cities and towns (Table 1) and transports the waste to the Nut Island sewage treatment plant. At Nut Island, primary treatment (except for sludge disposal) with seasonal chlorination is afforded before discharge. The average volume of sewage entering the Nut Island facility is 110 mgd. Approximately 30 percent of the oxygen demanding material is removed through treatment. The treated sewage is discharged through two five-foot diameter outfalls as shown in Figure 2. One outfall, at a depth of thirty feet, extends 6,000 feet from the plant;

EVERETT
CHELSEA
Mystic River
Chelsea River
Charlestown
East Boston
343,000
23,000
Logan International Airport
BOSTON
Charles River
BOSTON INNER HARBOR
WINTHROP
47,000
3,700
WINTHROP HARBOR
Deer Island
MASSACHUSETTS BAY
Roads
South Boston
65,000
6,000
BOSTON OUTER HARBOR
President
66,000
13,000
5,000
6,000
18,000
2,800
DORCHESTER BAY
Roxbury
22,000
3,400
Roads
27,000
5,900
Nantasket
9,000
880
17,000
4,700
1,800
290
Moon Island
HULL
Dorchester
Neponset River
1,300
255
244
15
HULL BAY
35
70
QUINCY BAY
3,700
500
Nut Island
HINGHAM BAY
748
105
423
65
QUINCY
Weir River
2,800
370
Weymouth Fore River
WEYMOUTH
HINGHAM
Weymouth Back River
0
1
2
Scale In Miles
MAJOR MUNICIPAL DISCHARGES AND AVERAGE COLIFORM DENSITIES
BOSTON HARBOR
MAJOR DISCHARGES
Location
Sewage Outfall
Sludge Outfall
AVG. COLIFORMS (MPN/100ml)
July-August 1967
Total Coliforms 0,000
Fecal Coliforms 000

FIGURE 2

TABLE 1

COMMUNITIES DISCHARGING SEWAGE TO THE
METROPOLITAN DISTRICT COMMISSION
SEWERAGE FACILITIES
(See Figure 1)

North Metropolitan System --	Arlington	Medford
	Bedford	Melrose
	Belmont	Reading
	Boston*	Revere
	Burlington	Somerville
	Cambridge	Stoneham
	Chelsea	Wakefield
	Everett	Wilmington
	Lexington	Winchester
	Malden	Winthrop
		Woburn

South Metropolitan System --	Ashland	Newton
	Boston*	Norwood
	Braintree	Quincy
	Brookline	Randolph
	Canton	Stoughton
	Dedham	Walpole
	Framingham	Waltham
	Hingham	Watertown
	Milton	Wellesley
	Natick	Westwood
	Needham	Weymouth

*Discharges to both systems.

the second outfall extends 1,400 feet from the plant at a depth of twenty feet. Digested sludge is discharged through a twelve-inch, 4.2 mile pipe in the President Roads area. This discharge of sludge greatly reduces the overall effectiveness of the treatment plant in terms of bacteria, oxygen demanding material, nitrogen and phosphorus removed.

Twenty metropolitan communities contribute wastes to the North Metropolitan system (Table 1). Approximately 350 mgd of sewage from this system is conveyed to Deer Island, the site of a new primary treatment plant which we understand has just become operational. The plant is designed to provide primary treatment (except for sludge disposal) or approximately 30 percent removal of the oxygen demanding material. Digested sludge and seasonally chlorinated effluent will be discharged to the harbor. The discharge of this sludge will greatly reduce the overall treatment effectiveness. Currently we understand that temporarily no sludge is being discharged with a resulting removal of 40 percent.

Sewage treated in a properly designed and operated primary treatment facility is capable of removing 30 to 35 percent of the oxygen demanding materials. However, unless the nutrients present in waste discharges are also removed, phytoplankton activity, such as that occurring in Boston Harbor, will produce oxygen depletions that will continue to endanger the aquatic life of the harbor. Adequate secondary treatment of sewage can reduce the nutrient content of the waste discharge and is capable of removing from 85 to 95 percent of the

organic matter and greatly reducing the coliform bacteria. Disposal of the digested sludge into the receiving waters increased the amount of nutrients and oxygen demanding material in those waters and reduces the overall efficiency of primary or secondary treatment facilities.

The Federal Government has not granted funds to the MDC for construction of the Deer Island sewage treatment facility because of the MDC method used for the discharge of sludge.

In addition to the above major sources of municipal waste, untreated sewage is still discharged at the City of Boston's Moon Island facility. In the Town of Hull, untreated sewage is discharged at three locations within the harbor.

INDUSTRIAL WASTES

The majority of the industries in the Boston area discharge to municipal sewerage systems. Complete listings of sources of industrial waste discharging directly to the waters of Boston Harbor are not available. Partial listings are in various stages of development by Federal, State and local agencies.

COMBINED SEWER OVERFLOWS

Portions of many of the cities and towns in the Boston Harbor drainage basin have combined sewer systems. During periods of heavy rainfall, when major interceptors reach their capacity, the local sewers overflow directly into the harbor and tributary streams. In some

instances, this overflow occurs during normal dry weather flow. There are more than 200 points of sewer relief in the Boston area which produce a significant bacterial, grease, solids and organic load in wet weather. Over ninety of the overflows discharge directly into the harbor.

TRIBUTARY STREAMS

The Chelsea, Mystic, Charles, Neponset and Weymouth Fore Rivers are severely degraded as they enter Boston Harbor. The Charles, Neponset and Mystic Rivers are the greatest contributors. Combined sewer overflows constitute a major source of pollution to the tributaries. Significant amounts of oil are added to the harbor from the Chelsea, Mystic and Weymouth Fore Rivers. These streams are major commercial waterways with many tank farms located along their shores.

FEDERAL INSTALLATIONS

Executive Order 11288 requires heads of Federal departments, agencies and establishments to provide leadership in the national effort to improve water quality through the prevention, control and abatement of water pollution from Federal activities in the United States. The Order requires that the Secretary of the Interior provide the necessary review, coordination and technical advice for all Federal departments, agencies and establishments. These, in turn, are required to cooperate with the Secretary, State and interstate agencies, and municipalities, insofar as practicable and consistent with the interests of the United

States and within available appropriations. Water pollution control requirements must be considered and included in the initial stages of planning for each new installation or project. Phased and orderly plans for installing water pollution abatement facilities at existing installations must be developed and periodically revised as required. The Secretary of the Interior has assigned the responsibility of implementing the Executive Order to the Federal Water Pollution Control Administration.

The Federal installations in the Boston Harbor area are listed in Table 2. Also included in this table are the present sanitary and industrial waste flows and their disposition at each installation. A brief description of the waste disposal practices of the major sources of sanitary and industrial wastes from Federal installations follows:

Boston Naval Shipyard

All sanitary wastes from the Boston Naval Shipyard (Charlestown) shore facility (average flow 0.3 mgd) are discharged to the Boston City Sanitary Sewer System. Cooling water (average flow 1.4 mgd) is discharged to Boston Harbor. Approximately 770 gallons per day of wastes from machine shop and tank cleaning operations are discharged directly to the Harbor. This discharge of industrial wastes is not in conformance with the requirements of Executive Order 11288 and corrective action is recommended.

TABLE 2

FEDERAL INSTALLATIONS--BOSTON HARBOR

NAME	AGENCY	LOCATION	QUANTITY IN G.P.D. SANITARY	INDUSTRIAL	TREATMENT	COMMENTS
Boston Army Base	Army	Boston	100,000		Boston City Sewer	
Family Housing Area	Army	Winthrop	2,960		Winthrop City Sewer	
Nike Ajax Site B-36	Army	Hull	6,000		Septic tank & Chlor. Discharge to Hingham Bay	Remedial action to comply with E.O. 11288 is recommended.
Windmill Point Lifeboat Sta.	Coast Guard	Hull	640		Hull Town Sewer	
Point Allerton Sta.	Coast Guard	Hull	1,920		Hull Town Sewer	
Deer Island Light Sta.	Coast Guard	Boston	240		None	Remedial action to comply with E.O. 11288 is recommended.
Boston Station	Coast Guard	Boston	20,000		Boston City Sewer	
Base Boston	Coast Guard	Boston		18,000	None	Cooling water for machinery and dynamometer.

TABLE 2 (CONTINUED)

NAME	AGENCY	LOCATION	QUANTITY IN G.P.D. SANITARY	INDUSTRIAL	TREATMENT	COMMENTS
Base Boston	Coast Guard	Boston	150		None	Two urinals on pier discharging directly to Boston Harbor. Plans are underway to eliminate.
Base Boston Vessels in Port	Coast Guard	Boston Harbor	22,000		None	Construction of a shore sewer line to collect sanitary wastes from berthed ships is scheduled for completion in late 1969 or early 1970.
Naval Hospital	Navy	Chelsea	102,500		Boston City Sewer	
Naval Shipyard	Navy	Boston	345,000		Boston City Sewer	
Naval Shipyard	Navy	Boston		1,424,000	None	Cooling water and
				770	None	wastes from machine shop and tank cleaning operations. Remedial action to comply with E.O. 11288 is rec.
South Boston Naval Annex	Navy	Boston	9,000		Boston City Sewer	
South Boston Naval Annex	Navy	Boston		342,000	Boston City Sewer	Water for generation of steam and in captive systems (hot water heating, cooling tower, etc.).

TABLE 2 (CONTINUED)

NAME	AGENCY	LOCATION	QUANTITY IN G.P.D. SANITARY	INDUSTRIAL	TREATMENT	COMMENTS
Naval Shipyard & South Boston Naval Annex (Berthed Ships)	Navy	Boston Harbor	40,500		None	Remedial action to comply with E.O. 11288 is recommended.
Naval Station	Navy	Boston	49,500		Boston City Sewer	
Squantum Gardens	Navy	Squantum Point	34,800		Quincy City Sewer	
Naval Terrace	Navy	Squantum Point	10,100		Quincy City Sewer	
Boston Motor Pool	G.S.A.	Boston	400		Boston City Sewer	
U.S. Appraisers Stores	G.S.A.	Boston	5,200		Boston City Sewer	
G.S.A. Stores	G.S.A.	Hingham	2,100		Hingham Town Sewer	
Food & Drug Admin.	H.E.W.	Boston	3,600		Boston City Sewer	

South Boston Naval Annex

All sanitary wastes from the shore facility (average flow 9,000 gallons per day) are discharged to the Boston City Sanitary Sewer System. Cooling water (average flow 0.3 mgd) is discharged through the Boston City Storm Drains to Boston Harbor.

Navy Ships Berthed in Boston Harbor

The sanitary wastes from all Naval ships berthed in the Harbor are discharged without treatment. The total flow discharged varies with the sizes and numbers of ships in port but is estimated to average 40,500 gallons per day. The Navy is engaged in a program to abate pollution from its vessels, and as part of this program has installed a treatment device on board a destroyer based in Boston. This device is currently undergoing testing and evaluation. Corrective action is recommended to eliminate pollution by naval vessels.

Coast Guard's Base Boston

Sanitary wastes from two urinals located on one of the piers, all sanitary wastes from Coast Guard ships berthed at Base Boston and cooling water from the Base are discharged directly into the Harbor. All other sanitary wastes from the facility are collected by the Boston sewer system.

Plans for the removal of the urinals and for a sewer to collect sanitary wastes from berthed ships with discharge to the Boston sewer system are nearing completion. The project is scheduled for completion in late 1969 or early 1970.

Nike Ajax Site B-36 (Hull)

Six thousand gallons per day of sanitary wastes are passed through a septic tank and chlorinated before discharge to the Harbor. This is not in conformance with Executive Order 11288. Secondary treatment is recommended.

WATERCRAFT WASTES

Sewage from almost all vessels using Boston Harbor is discharged without treatment; these watercraft contribute to the pollution problem. Recreational boating activity is centered in waters also used for bathing and recreational fishing. As boating use in the harbor increases, greater pollution will result, unless steps are taken to prevent raw sewage discharges.

Approximately 80 percent of the cargo transported through the port of Boston are petroleum products. The discharge of oil and oil materials from watercraft is a serious pollution problem, whether it is an accidental spill or oily waste waters from ballast tanks, bilges or washing operations. Boston Harbor had a total of twenty-nine oil spills reported in 1966 and 1967.

DEBRIS AND REFUSE

Floating debris and refuse are esthetically unpleasant and a danger to shipping; they can also be a source of organic waste. The major cause of the debris problem in the harbor is dilapidated piers and wharves. Refuse dumped along the shore, litter contributed by vessels, and garbage spilled during barging and burning operations are the main sources of solid waste.

OTHER SOURCES

Water quality may be adversely affected by a variety of other land and water activities. For instance, urban runoff from streets and parking lots can add significant amounts of organic and suspended materials. The disturbance of bottom muds by dredging operations can result in a resuspension of accumulated organic sludges and silt and the smothering of shellfish.

The City of Boston sewerage system was constructed in the late 1800's. From past experiences in large cities, it is likely that some local sewers, for which there are no records, have never been intercepted and are presently discharging sewage directly to the harbor and tributaries.

EFFECTS OF POLLUTION ON WATER USES

SHELLFISH HARVESTING

Records at the Massachusetts Department of Natural Resources, Division of Marine Fisheries, disclosed that the commercial shellfish production from Boston Harbor and certain other areas has played a small but significant role in the economy of the shellfish industry in the Bay State. For the purpose of this report, the shellfish production is confined to the harvesting and preparation for marketing of the soft-shelled clam (Mya arenaria) available in the intertidal waters of Boston Harbor. As a result of pollution of the growing areas, most of the shellfish harvested commercially in Boston Harbor may be marketed for human consumption only after an effective method of treatment has been applied.

Official Control of Shellfish Harvesting. Commercial and private harvesting of shellfish in Boston Harbor is controlled by two means--the classification of shellfish beds by Massachusetts in order to protect the public health, and the issuance of permits by the towns to individuals for either commercial or sport digging of shellfish.

The shellfish harvest areas are defined by the State Department of Public Health as the waters and flats of Boston Harbor, including all its arms and tributaries inside of a line drawn from Windmill Point in Hull to the southeasterly point of Deer Island and through

Deer Island to Point Shirley and including the shores of Lovell, Gallops and Georges Islands. These areas have been defined and established as shellfish grounds as far back as 1937 and have continuously been redefined and surveyed. Table 3 lists the shellfish areas in Boston Harbor.

The commercial harvesting of shellfish is based on the quality of the overlying waters in the shellfish beds. Under the law, the Massachusetts Department of Public Health is held responsible for the classification of all shellfish beds through a series of sanitary and bacteriological surveys. As a cooperating member of the National Shellfish Sanitation Program for interstate shipment of shellfish, the state must also abide by Federal regulations. The coastal waters of Massachusetts, therefore, are divided into distinct bacteriological classifications in accordance with the Shellfish Sanitation Manual requirements of the National Shellfish Sanitation Program. This program is a cooperative partnership between the State, other cooperating member states and the United States Public Health Service. In general, the overlying waters of the shellfish beds are delineated under the following three bacterial classifications:

1. Approved areas: waters with a coliform median MPN (most probable number) not to exceed 70 per 100 ml. Shellfish may be harvested and sold from approved areas for direct marketing.

TABLE 3

SHELLFISH AREAS
BOSTON HARBOR

Area Harvesting Classification	City or Town	General Location	Area Code	Total Acres
Prohibited (1941 Closure)	-	**Boston Harbor**	-	**1,560**
Prohibited (Since June 1967)	Boston	Logan Airport, southeast	BH A	
	Boston	Logan Airport, northeast	BH B	
	Boston	Logan Airport, northwest	BH C	
	Boston	Old Harbor	BH 4	
	Boston	Pleasure Bay	BH 4A	
	Hull	Allerton Harbor	BH 13	
	Hull	Hog Island	BH 17	
	Hull	Sunset Point	BH 14*	
	Quincy	Germantown Point	BH 8B	
	Quincy	Neponset River, Squantum Point	BH 5	
	Quincy	Town River Bay	BH 8A*	
	Weymouth	Eastern Neck, Wessagusset Beach	BH 9*	
				1,113
Restricted	Boston	Orient Heights	BH D	
	Hingham	Bumpkin Island	BH 12	
	Hingham	Crow Point, west	BH 11	
	Hingham	Weymouth Back River	BH 9A	
	Hull	Sunset Point	BH 14*	
	Hull	Weir River	BH 15	
	Hull	Weir River	BH 19	
	Hull	Weir River	Weir River	
	Quincy	Hough's Neck	BH 7	
	Quincy	Hough's Neck, east	BH 8	
	Quincy	Quincy Bay	BH 6	
	Quincy	Squantum	BH 5B	
	Quincy	Town River Bay	BH 8A*	
	Weymouth	Eastern Neck, Wessagusset Beach	BH 9*	
	Weymouth	Grope Island	BH 18	
	Weymouth	Kings Cove	BH 9B	
	Weymouth	Mill Cove, east	BH 9C	
	Weymouth	State Island	BH 10	
	Weymouth	Weymouth Back River	BH 16	
	Winthrop	Point Shirley, west	BH 1	
				1,319
Approved	Hingham	Hingham Harbor	-	
	Hingham	Weir River, west	-	
	Hull	Hull Bay	-	
	Quincy	Quincy Bay	-	
				500
			TOTAL	**4,492**

*Indicates a partial closure. Part of the area is classified prohibited and part restricted.

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2. Restricted areas: waters with a coliform median MPN not to exceed 700 per 100 ml. Shellfish may be harvested but must be treated in a State-approved depuration plant before being sold.

3. Prohibited areas: waters with a coliform median MPN that is greater than 700 per 100 ml. Shellfish may not be harvested for human consumption.

A complete statement of the classification requirements is given in Appendix A. As a result of potential contamination from sewage treatment plant effluents, certain approved areas beyond the outfall may be classified as "conditional," that is, shellfish may be harvested and sold, provided that certain specified conditions concerning the potential pollution source and other factors are met. Seasonal closures are limitations applied to specific growing areas as a result of seasonal activities such as recreational boating, shipping and seasonal chlorination practices.

There are 4,492 acres of available shellfish growing beds in Boston Harbor. In 1941, all of these beds were closed and shellfishing was prohibited with the exception of thirty-three areas covering 2,932 acres. Twenty-nine were classified as restricted; four, located in Quincy, Hull and Hingham, were open. On June 1, 1967, shellfish beds in the Old Harbor area were reclassified as prohibited. Subsequently, eleven other sections, including three partial closures,

were similarly classified. As of April 1, 1968, there were the original closure areas covering 1,560 acres; twelve prohibited areas covering 1,113 acres; seventeen restricted areas covering 1,319 acres; and four approved areas covering 500 acres (see Table 3 and Figure 3). The Massachusetts Department of Public Health is currently studying the water quality over the four approved areas. Preliminary indications are that these beds are marginal.

Massachusetts law requires that all commercial shellfish harvesters register with the Department of Natural Resources, Division of Marine Fisheries, for the privilege of taking shellfish for marketing. Two types of annual permits issued for harvesting in the shellfish areas of Boston Harbor are of particular interest. One type of permit is conferred to "Master Diggers." Each Master Digger must meet the requirements of the permit and post a $500 bond. Another permit is called a "Subordinate Digger's" license which, subject to regulations, provides that the digger may labor only under the employ and supervision of a licensed Master Digger. All shellfish obtained from restricted areas, as required by law, must be properly cleansed at a state supervised depuration plant before being released for direct marketing to the consumer. To insure the safety of the product, the state has made available to the Master Diggers a shellfish treatment plant, located thirty-five miles north of Boston in Newburyport, Massachusetts, which is maintained and operated by the Division of Marine Fisheries. The cost of treating the shellfish is shared by the Master Diggers and the cities and towns from which the shellfish are obtained.

EVERETT
CHELSEA
Mystic River
Chelsea River
Charlestown
East Boston
WINTHROP
Logan International Airport
BOSTON
Charles River
BOSTON INNER HARBOR
WINTHROP HARBOR
MASSACHUSETTS BAY
N
Lovell Island
Roads
South Boston
BOSTON OUTER HARBOR
President
Old Harbor
Roxbury
DORCHESTER BAY
Gallops I.
Lovell I.
Reeds
Thompson Island
HULL
Dorchester
HULL BAY
QUINCY BAY
Nut Island
HINGHAM BAY
QUINCY
Slate I.
Weymouth Fore River
WEYMOUTH
Weymouth
Back River
HINGHAM
SHELLFISH AREA CLASSIFICATIONS
BOSTON HARBOR
APRIL, 1967
Approved
Restricted
Prohibited
0
1
2
Scale in Miles

FIGURE 3

In an ordinary year, about twenty Master and 180 Subordinate Digger permits are issued by the Division of Marine Fisheries for the harvesting of shellfish in Boston Harbor and in other areas along the northern Massachusetts coast. Table 4 lists the number of permits issued to Master and Subordinate Diggers by individual cities and towns from 1963 to 1967.

Records of the number of harvesting permits issued for the period 1963 to 1967 showed that there was a general decline in the Subordinate Diggers group, while the Master Diggers group showed only a slight reduction in numbers. The data indicated that only 36 percent of the licensed Master Diggers and over 71 percent of the Subordinate Diggers harvested shellfish in Boston Harbor. The remaining diggers harvested in areas on the northern coast of Massachusetts. Forty-one percent of the Subordinate Diggers were licensed in Quincy and 26 percent in Boston. Quincy also had the most Master Diggers, 35 percent; Weymouth had 23 percent. The records do not tell whether the permits are used by the harvesters for full-time or part-time employment.

Production of Shellfish. The number of outlets available to the Master Diggers is estimated to be 100 wholesale dealers, 60 eating establishments and 140 retail outlets and markets. Additional outlets are located in New Hampshire. Since all of the shellfish taken out of Boston Harbor, except those dug in the few open areas, must be treated at the Newburyport shellfish treatment plant. A record of the plant's activity serves as an indicator of shellfish production in Boston Harbor.

TABLE 4

MASTER AND SUBORDINATE DIGGER PERMITS[1]
NORTHERN MASSACHUSETTS COAST

1963-1967

	1963		1964		1965		1966		1967		Avg.		Percent	
Permit Issued By	M	S	M	S	M	S	M	S	M	S	M	S	M	S
Boston Harbor														
Boston	2	39	0	51	0	50	0	0	0	29	0.4	33.8	5.9	26.5
Chelsea	0	1	0	1	0	8	0	3	0	3	0.0	3.2	0.0	2.5
Everett	0	1	0	0	0	0	0	0	0	0	0.0	0.2	0.0	0.2
Hingham	1	3	1	2	1	2	1	1	1	1	1.0	1.8	14.7	1.4
Hull	0	7	0	1	0	2	0	2	0	0	0.0	2.4	0.0	1.9
Malden	0	0	0	1	0	0	0	1	0	1	0.0	0.6	0.0	0.5
Milton	0	0	0	0	0	0	0	1	0	1	0.0	0.4	0.0	0.3
Quincy	2	58	2	58	4	61	2	42	2	47	2.4	53.2	35.3	41.8
Somerville	0	0	0	0	0	0	0	1	0	1	0.0	0.4	0.0	0.3
Weymouth	3	34	2	17	2	19	0	18	1	18	1.6	21.2	23.5	16.6
Winthrop	1	13	3	13	1	15	1	5	1	5	1.4	10.2	20.6	8.0
SUB-TOTAL	9	156	8	144	8	157	4	74	5	106	6.8	127.4	100.0	100.0
Boston Harbor	9	156	8	144	8	157	4	74	5	106	6.8	127.4	36.2	71.6
Non-Boston Harbor[2]	12	59	12	48	12	60	11	40	13	42	12.0	50.6	63.8	28.4
TOTAL	21	215	20	192	20	217	15	114	18	148	18.8	178.0	100.0	100.0

M=Master Digger Permit

S=Subordinate Digger Permit

1. Source: Massachusetts Division of Marine Fisheries
2. Non-Boston Harbor: Gloucester, Lynn, Newbury, Newburyport, Peabody, Revere, Rowley, Saugus and Scituate

The plant also serves six other communities. These communities, not located within the Boston Harbor area, have contributed about 18 percent of the annual amount of the shellfish processed at the plant over the past seven years, while the communities within the harbor accounted for 82 percent. Of the Boston Harbor portion, Boston and Quincy produced almost 84 percent of the total, or 69 percent of the total number of clams processed at the plant (Table 5).

The volume of shellfish treated at the Newburyport plant from 1935 through 1967 is shown in Figure 4. By dividing the twenty-eight years of record into quartiles of seven years each, the average annual rate of clam treatment and the resulting percent gain or decrease from the period 1940-1946 can be shown as follows:

Years of Record	Annual Rate of Treatment (bu.)	Est. Boston Harbor Rate (82% of Total)	Percent
1940-1946	47,100	39,000	Base Line
1947-1953	54,700	41,000	+16.1
1954-1960	37,600	31,000	-25.5
1961-1967	14,600	12,000	-66.1

A definite decrease in shellfish production is shown during the last ten years. The peak production was in 1951 when 93,700 bushels were processed, which 7.8 times the 1967 rate of 12,000 bushels. For the last seven years, the production from Boston Harbor has averaged 12,000 bushels.

Monthly processing records for the plant at Newburyport are shown in Figure 5, and indicate that 65 percent of the shellfish are treated from May to September, inclusively.

TABLE 5

GEOGRAPHICAL DISTRIBUTION OF PROCESSED CLAMS

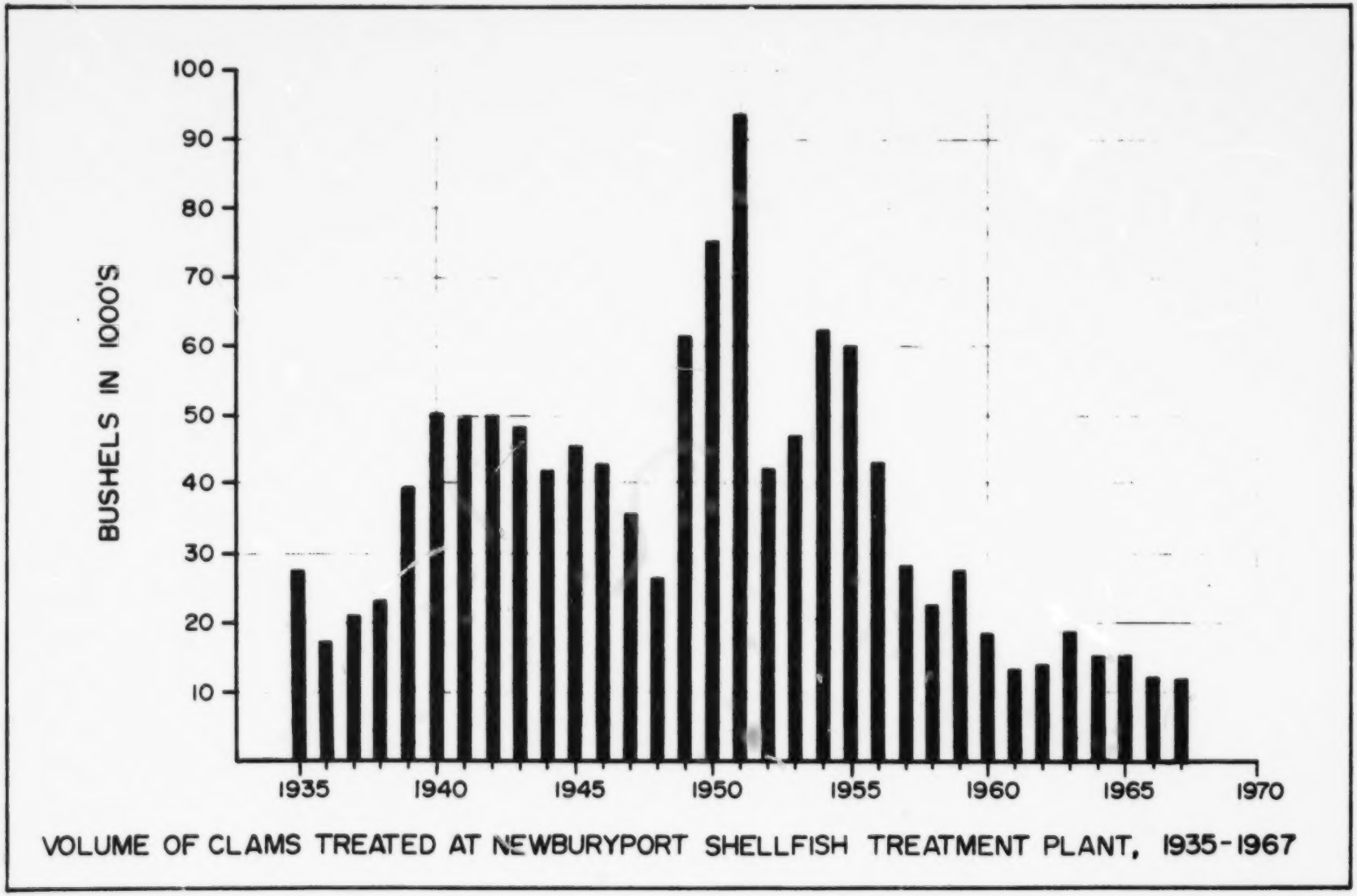
NEWBURYPORT SHELLFISH TREATMENT PLANT

1961-1967

Volume of clams in bushels

City or Town	1961	1962	1963	1964	1965	1966	1967	Total	Percent
Boston Harbor									
Boston	3,722	5,346	7,902	6,258	4,832	3,787	4,763	36,605	43.5
Hingham	437	0	315	209	154	90	113	1,318	1.5
Hull	0	718	926	381	132	131	411	2,699	3.2
Quincy	3,839	5,143	5,175	4,125	6,114	5,198	4,417	34,011	40.4
Weymouth	2,086	1,465	1,484	535	565	859	229	7,223	8.6
Winthrop	1,326	144	308	583	0	0	0	2,361	2.8
SUB-TOTAL	11,410	12,816	16,110	12,091	11,797	10,060	9,933	84,217	100.0
Boston Harbor	11,410	12,816	16,110	12,091	11,797	10,060	9,933	84,217	82.4
Non-Boston Harbor*	1,996	1,422	2,697	3,522	3,990	2,225	2,085	17,937	17.6
TOTAL	13,406	14,238	18,807	15,613	15,787	12,285	12,018	102,154	100.0

*Gloucester, Ipswich, Newbury, Newburyport, Revere and Saugus.



VOLUME OF CLAMS TREATED AT NEWBURYPORT SHELLFISH TREATMENT PLANT, 1935-1967

FIGURE 4

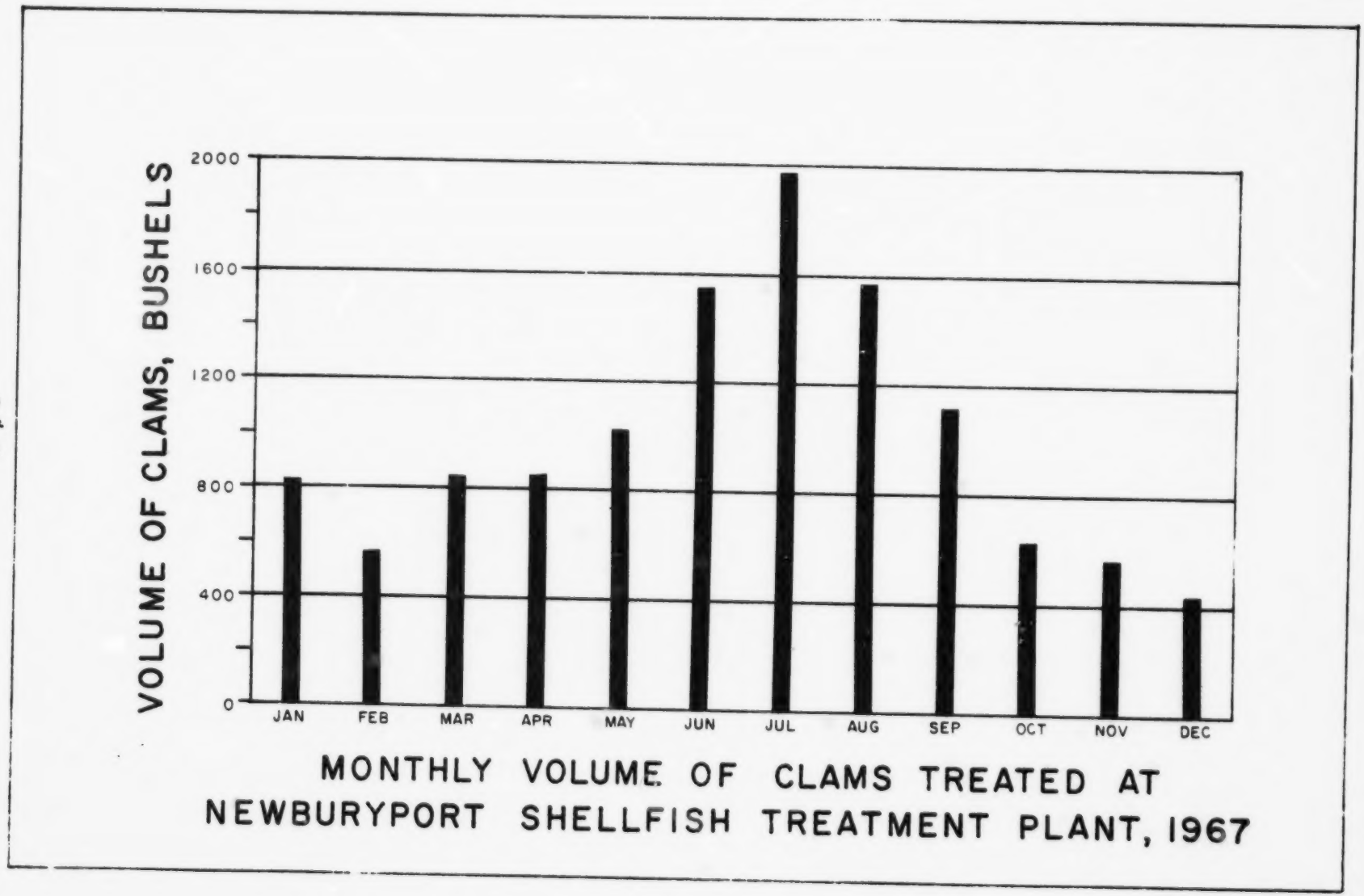

VOLUME OF CLAMS, BUSHELS
2000
1600
1200
800
400
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTHLY VOLUME OF CLAMS TREATED AT
NEWBURYPORT SHELLFISH TREATMENT PLANT, 1967

FIGURE 5

3f. B

Economic Value of Shellfish. On the wholesale market, the shellfish are sold and delivered in 65-pound bushel units. The prices of soft-shelled clams are seasonal. During the winter months, the market demands are small; however, as warmer weather and the tourist season approach, the prices inevitably rise. Prices vary from a low of eight dollars to a high of twelve dollars per bushel. Using an annual shellfish production rate for Boston of 12,000 bushels, the rate in recent years, it can be estimated that the basic shipper market value of the shellfish at $10 a bushel would amount to $120,000 a year.

Shellfish sanitation control officials estimated that over 90 percent of the shellfish processed at the shellfish treatment plant is generally consumed as steamer clams. By allowing one quart of shellfish to a person, the annual production of treated Boston Harbor shellfish would reach well over 410,000 consumers. Of the more than 90 percent shellfish confined to the steamer market, it was estimated that 30 percent is consumed at commercial picnic clam-bakes or in restaurants and the remaining 70 percent is sold in the retail markets as shellstock over the counter.

Records of the Division of Marine Fisheries show that during the period of July 1, 1966, to June 30, 1967, 12,000 bushels of clams were treated at the Newburyport shellfish treatment plant. Eighty-two percent, or 9,900 of the 12,000 bushels were harvested from Boston Harbor. A review of Master Digger records for the same year indicates that 7,800 bushels, 79 percent, of the treated Boston Harbor shellfish were taken from the twelve areas closed by the State Department of Public Health since June 1, 1967.

The economic damage resulting from pollution caused the production loss of 7,800 bushels of shellfish, representing an annual shipper market loss of $78,000 and a general retail loss of $530,000 to $1,300,000. The result of the closure of these shellfish growing areas is summarized in Table 6.

Several factors other than the closing of shellfish beds add to the economic loss. Shellfish beds may be damaged or destroyed by dredging or landfill operations or by the toxic effects of waste discharges. Physical damage or "market refusal" may result from oil spills. The economic damage from such factors is not calculable. Should the water quality of Boston Harbor become further degraded, the State would have no choice but to impose additional limitations.

RECREATIONAL BATHING

Water, polluted by sewage, contains enormous amounts of coliform bacteria that occur typically in the excreta of warm-blooded animals.

TABLE 6

ESTIMATED ANNUAL ECONOMIC DAMAGE TO THE SHELLFISH INDUSTRY IN BOSTON HARBOR

Item	Before June 1, 1967	Amount of Loss	After April 1, 1968
No. of areas	33	9 (plus 3 partial)	21
Acreage	2,932	1,113	1,819
1967 Shellfish Production	9,800 bu (100%)	7,800 bu (79%)	2,000 bu (21%)
Landed Market Value	$98,000	$78,000	$20,000
Minimum Value to the Food Industry	$670,000	$530,000	$138,500
Maximum Value to the Food Industry	$1,670,000	$1,320,000	$350,000

Production based on year ending June 30, 1967.

These bacteria, while not usually harmful in themselves, are used as indicators of fecal pollution and of the possible presence of pathogenic bacteria. Pathogens, if ingested, can cause gastrointestinal diseases. In order to protect the public health and to maintain a high degree of water quality, the Commonwealth of Massachusetts has established a limit, based upon the presence of coliform bacteria, to differentiate between "safe" and "hazardous" swimming waters. A median total coliform value of less than 700 per 100 ml is used to classify coastal waters as SA or SB. (Pages 8, 9 and 10 contain the Massachusetts classifications.) These waters are considered to be safe for swimming and other water contact activities.

In the harbor, bacteria from human wastes constitutes a major water pollution problem. Beaches in Winthrop have been closed to bathing since 1962 as a result of bacterial pollution. Investigations have indicated that the MDC municipal waste discharge at Deer Island is the major source of bacterial pollution of the Winthrop-East Boston section of Boston Harbor. Several other bathing areas in the harbor have been threatened with closure.

In the Boston regional area the bathing beaches are overcrowded. In 1965 all of the Boston swimming areas combined could only accommodate 11,100 bathers. The number of persons on an average weekend in the summer desiring access to swimming areas will reach 49,000 by 1970.

There are ten public beaches, operated by the MDC, and several small municipal beaches in the harbor. The MDC beaches cover an area of 640 acres, including over 5.4 miles of shore.

The Metropolitan Area Planning Council has recently completed an open space and recreation study of Boston Harbor. The Council considers the harbor a major recreational center for the Boston area and recommends a program of open space acquisition and development. The recreation plan includes substantial increases in bathing and sport fishing areas and the establishment of additional boating facilities. The MAPC, however, points out, "No improvement or recreational development of the harbor is possible without an end to pollution."

RECREATIONAL BOATING

Recreational boating in the harbor has been limited by the appearance of the water. The discharge of suspended solids to the receiving waters imparts a gray turbidity to the waters. Dense growths of unsightly attached marine plants stimulated by nutrients are prevalent throughout the harbor at most buoy, pier and marine facilities. Floating debris in the harbor is esthetically unpleasing and a safety hazard, having caused damage to recreational boats.

The demand for recreational boating has increased rapidly in recent years and presently exceeds the supply of launching and mooring facilities. Within the harbor there are twenty-eight recreational

boat launching facilities. In addition to trailered boats, there are approximately 5,000 pleasure boats moored in the harbor. Thirty-five private yacht clubs and thirty-two commercial marinas provide these mooring facilities.

SPORT FISHING

Sport fishing is an important water use in Boston Harbor. Surf fishing is particularly popular off the beaches of Hull, Quincy and Winthrop. Pier fishing is heavy in the South Boston area. In addition, there are several professional charter boat operators who cater to fishing parties.

ESTHETICS

Nutrients and suspended solids have caused undesirable odor problems to certain areas of Boston Harbor.

Extensive growths of sea lettuce are prevalent in three tidal flat areas of Boston Harbor, Winthrop Harbor, Squantum Bay and along the shores of Nut Island. These growths have been stimulated by very high concentrations of inorganic nitrogen and phosphorous contributed by sewage discharges. During low tide, the sea lettuce becomes exposed to air and sun and the plants decompose, producing hydrogen sulfide odors. There are reports that Winthrop Harbor residents have been forced to leave their homes to escape the smell. Hydrogen sulfide emissions from decaying sea lettuce has discolored homes. A contributory cause of the sea lettuce problem in Winthrop Bay is the nutrients added to the harbor from the Deer Island sewage treatment plant.

Upon discharge of suspended solids, the heavier solids settle to the harbor bottom in the vicinity of the points of discharge and form sludge deposits. The organic material in the sludge undergoes a decomposition which utilizes the dissolved oxygen in the overlying waters. When complete depletion of oxygen occurs, the further decomposition of organic matter produces obnoxious hydrogen sulfide gas which bubbles to the surface. Masses of the deposited sludge rise with the gas to the surface, where they appear as gray or black odorous clumps and rafts. Sludge deposits in the Fort Point Channel in South Boston are over three feet deep as a result of several combined sewer overflows. The dissolved oxygen is seriously depleted, resulting in undesirable odors from the anaerobic decomposition of the sludge.

COMMERCIAL SHIPPING

The Boston port facilities are concentrated along the Boston Inner Harbor and the Mystic, Chelsea and Weymouth Fore River areas. The main ship channel has a controlling depth of forty feet; other channels range from fifteen to forty feet.

In 1965 there were 10,574 inbound trips of commercial vessels into the harbor and 10,604 outbound trips. Passenger and dry cargo vessels constituted 54 percent of the trips, tankers constituted 24 percent and the remaining 22 percent were attributed to tugboats or or towboats. Movements of freight within the confines of the harbor numbered 14,954, of which 72, 15 and 13 percent were from passenger and dry cargo vessels, tankers and tugboats, or towboats, respectively.

WATER SUPPLY

Harbor water is used by coastal industries for cooling and processing. In 1965 several million gallons of harbor water a day were used. Over 99 percent of this total was for cooling purposes.

PRESENT WATER QUALITY

The summary of water quality parameters bacteria, dissolved oxygen, benthic life, nutrients and benthal deposits, presented in this report are based upon a survey of Boston Harbor conducted during July and August 1967 by the Federal Water Pollution Control Administration. Data obtained during the field investigations are available from two reports: "Chemical and Physical Aspects of Water Quality, Charles River and Boston Harbor, Massachusetts," February 1968; and "Biological Aspects of Water Quality, Charles River and Boston Harbor, Massachusetts," January 1968, United States Department of the Interior, Federal Water Pollution Control Administration.

BACTERIA

Water polluted by wastes from warm-blooded animals, including humans, frequently contain pathogenic bacteria. Ingestion of these pathogens by drinking polluted water or by eating raw or partially cooked shellfish grown in these waters can cause gastrointestinal diseases such as typhoid fever, dysentery and diarrhea. The infectious hepatitis virus, as well as other enteric viruses, may also be present. Body contact with water polluted by bacteria can also cause eye, ear, nose, throat or skin infections. Therefore, bacterial pollution presents a health hazard, not only to those who come in contact with polluted waters, but also to those who may eat shellfish taken from the waters.

sewage and some industrial wastes also contain bacteria of the coliform group which typically occur in excreta or feces of warm-blooded animals and are readily detectable. Although most are harmless in themselves, coliform bacteria are always present in waters polluted by warm-blooded animal wastes and are considered indicators of the probable presence of pathogenic bacteria. The Commonwealth of Massachusetts evaluates water quality on the basis of sanitary survey findings and total coliform content. Recently, refined methods for isolation and detection of Salmonella organisms have made it practical to test for these specific pathogenic bacteria.

The coliform group usually is designated as total coliforms, and most bacterial standards are set using total coliform limits. Included in the total coliform bacteria are fecal coliforms. A separate test can be performed on a water sample to determine the number of fecal coliforms present. Since fecal coliforms can only come from warm-blooded animals, they are considered proof of fecal pollution. The results of the determinations are expressed in terms of coliforms per 100 milliliters of water. One hundred milliliters is approximately one-half cup.

The chain of disease transmission by pathogenic bacteria from human waste through shellfish which are eaten raw or insufficiently cooked, has been well established. In an attempt to control such disease transmission, the National Shellfish Sanitation Program was established in 1925. This is a cooperative program between the States, the Public

Health Service, and the shellfish industry, with the goal of safely utilizing this valuable natural resource. The Massachusetts Department of Public Health uses the guides set forth in the National Shellfish Sanitation Manual of Operations, Part I, to properly classify the suitability of estuarine waters for shellfish harvesting. The water quality standards adopted by the Massachusetts Water Resources Commission follow similar guides for the bacterial quality of Class SA, SB and SC waters. However, the water quality classifications do not necessarily mean that the shellfish beds, under the guides of the National Shellfish Sanitation Program, will be classified in the same manner. The guides are summarized below.

Shellfish Bed Classification	Water Quality Classification	Bacterial Water Quality Requirements*
Approved or Open Beds	Class SA	Coliform bacteria not to exceed a median value of 70 per 100 ml.
Restricted	Class SB	Coliform bacteria not to exceed a median value of 700 per 100 ml.
Prohibited or Closed Beds	Class SC	Coliform bacteria exceeds that of the restricted areas.

*Refer to Appendix A for the National Shellfish Sanitation Program requirements and pages 8, 9 and 10 for the Massachusetts water quality standards.

Licensed, commercial diggers, harvesting from shellfish beds classified as approved, are permitted to sell directly to the wholesale

and retail market. A restricted classification requires that the harvested shellfish be treated in an approved shellfish treatment plant to remove the excess bacteria. This process of cleansing shellfish is called depuration. (For Boston Harbor the depuration facility is located in Newburyport, Massachusetts.) No harvesting of shellfish for human consumption is permitted from prohibited shellfish beds.

During the 1967 study of Boston Harbor, excessive counts of coliform bacteria were found. Total coliform counts as great as 520,000 per 100 ml were found in the Inner Harbor area. In general, very high counts were found in the northern portion of the harbor, while Quincy, Hingham and Hull Bays in the southern portion would probably meet Class SB water quality criteria for bacteria. One station in western Quincy Bay would probably satisfy the coliform standards of Class SA waters. Average total coliform concentrations found during July and August of 1967 are shown in Figure 2.

Tests for pathogenic bacteria of the genus Salmonella were conducted in Boston Harbor. Three of the five sampling swabs placed in the harbor to collect these organisms were positive for Salmonellae. Since almost all serotypes of Salmonella are known to be disease-producers in warm-blooded animals, including man, their presence in these waters is proof of a continuing health hazard.

DISSOLVED OXYGEN

The oxygen demand of sewage and industrial wastes, as measured by the biochemical oxygen demand test, indicates the waste's potential

for reducing the dissolved oxygen content of the receiving water. Adequate levels of dissolved oxygen are necessary to support fish and other aquatic life. If dissolved oxygen becomes totally depleted, obnoxious odors, mostly from hydrogen sulfide gas result, causing an unpleasant environment for persons living or working nearby. The hydrogen sulfide given off may turn nearby houses, bridges or other painted structures black.

Water Quality Standards adopted by Massachusetts require that for Class SB water the dissolved oxygen be "not less than 5 mg/l at any time" and for Class SC water, the lowest classification of salt water, "not less than 5 mg/l during at least 16 hours of any 24-hour period, nor less than 3 mg/l at any time." Of the eighteen stations sampled during July and August of 1967, only six met the Class SC standard. Furthermore, only two stations met the tentative recommendations of the National Technical Advisory Committee, that "Dissolved oxygen concentrations in estuaries and tidal tributaries shall not be less than 4.0 mg/l, at any time or place..." "...for the protection of marine resources..."

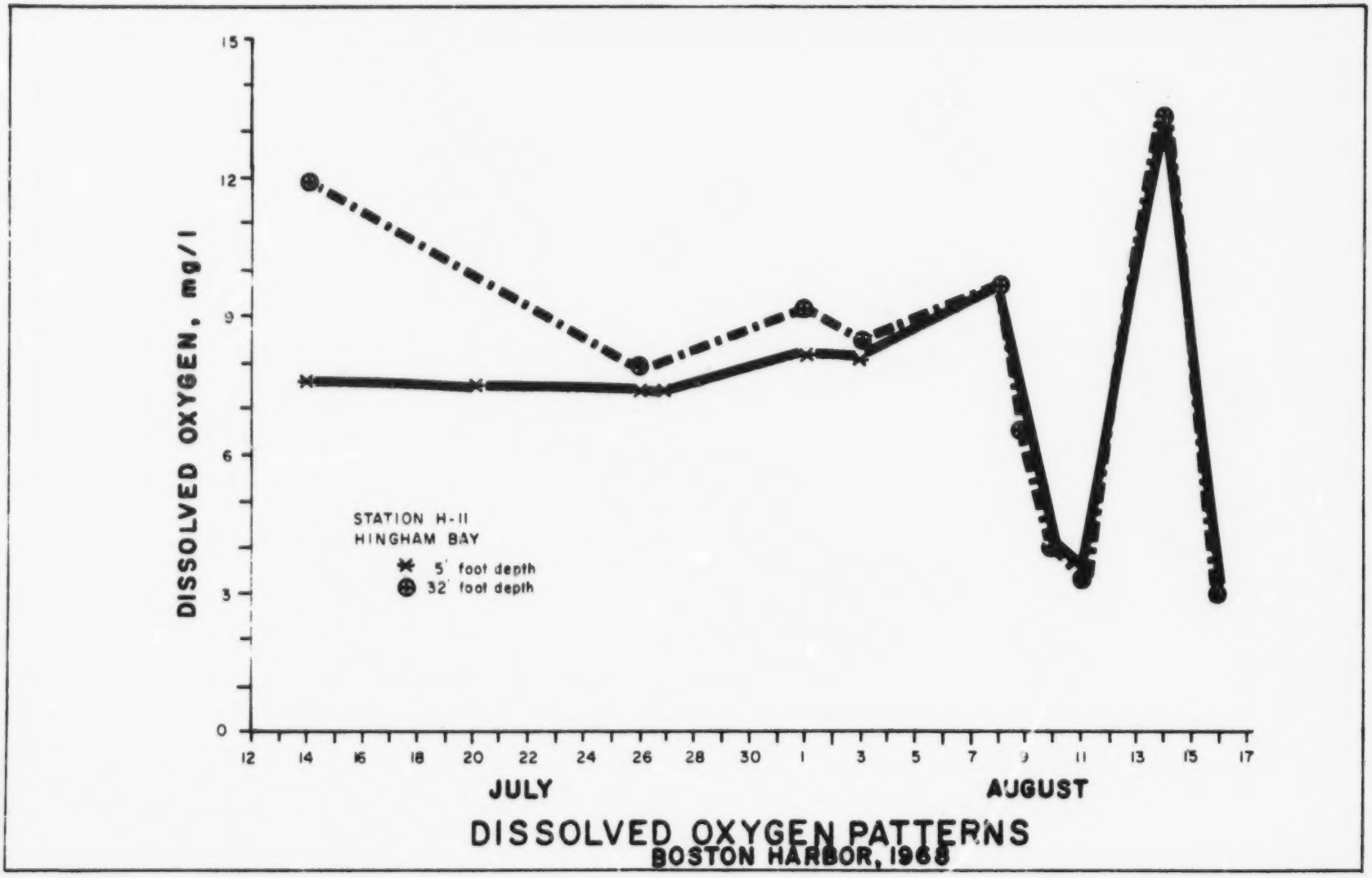
Excessive phytoplankton activity is suggested by the wide fluctuation of dissolved oxygen during the latter portion of the 1967 survey (Figure 6). Under normal conditions, phytoplankton, primarily algae, produce oxygen by photosynthesis and utilize oxygen by respiration. However, when excessive nutrients and sunlight are present, the phytoplankton population can rapidly expand, resulting in high dissolved

oxygen caused by an accelerated photosynthesis. During night or heavily clouded periods of daylight, the respiration of this expanding population can overtax the dissolved oxygen supply of the water, resulting in serious oxygen depletions.

BENTHIC LIFE

The benthic organism community is a convenient measure of the degree of organic pollution. If the water is not grossly polluted, the benthic population would be comprised of several kinds of organisms, each with a relatively low population. Certain clams, crabs, nematode worms, starfish, shrimp, sowbugs and mussels would normally be present. Grossly polluted areas would normally have a few kinds of organisms in great abundance. Organisms such as polychaete worms and scuds would be dominant.

All reaches of Boston Harbor and each of its tributary streams, except the inland marine reaches of the Weir and Weymouth Back Rivers, were polluted. This was evidenced by a paucity of kinds of organisms associated with benthic deposits. Polychaete worms were found in all harbor sediments; in fact, they were the only life-forms found at three stations. Scuds were also found at a majority of the sample points. These two groups of benthic organisms were dominant in kind and number over the few sowbugs, shrimp, snails, nematode worms and starfish found at the other stations. Polychaete worms were considered sufficiently common to show areas and degrees of organic over-enrichment.



DISSOLVED OXYGEN PATTERNS
BOSTON HARBOR, 1968

FIGURE 6

A density of polychaetes greater than 200 per square foot is considered indicative of excessive enrichment. This density was exceeded in all of Boston Harbor except those waters associated with the inland sectors of Quincy Bay and those seaward along a relatively narrow course through Nantasket Roads to the southern mouth of the harbor at Massachusetts Bay (Figure 7). About seven square miles, or 30 percent of the harbor inland from Massachusetts Bay, were grossly polluted based upon polychaete worm densities in excess of 200 per square foot.

NUTRIENTS

The average values of ammonia nitrogen and soluble phosphorous were equal to or greater than 100 and 40 micrograms per liter, respectively, in all areas of Boston Harbor inland from its mouth near Massachusetts Bay. Such high concentrations of nutrients caused overly enriched conditions that stimulated dense populations of phytoplankton which exceeded 1,000 per milliliter in about sixteen square miles, or 66 percent of the harbor. Areas of excessive nutrient concentrations, as indicated by phytoplankton, are shown on Figure 8.

In addition to causing excessive phytoplankton populations, the nutrients stimulated dense growths of attached marine plants. Observations throughout Boston Harbor disclosed such growths on most buoy, pier and marine facilities. Several intertidal and shallow areas of the harbor and certain reaches of Winthrop Bay supported dense growths of attached

marine algae. These caused noxious conditions in Winthrop Bay, unsightly growths at marine facilities and increased maintenance costs associated with buoys and piers. In Winthrop Bay, decomposing masses of sea lettuce have caused hydrogen sulfide emissions sufficient to discolor paint on nearby dwellings.

BENTHAL DEPOSITS

Municipal and industrial wastes discharged into the receiving waters of Boston Harbor resulted in extensive deposits of decaying organic matter and incorporated oily residues covering much of the harbor bed. Oily sludge deposits in the Fort Point Channel were more than three feet deep. Hydrogen sulfide gas bubbles effervescing from the sludge in this reach, rose to the surface and burst, creating the odor of rotten eggs. Although not as deep, sludge with similar oil composition and hydrogen sulfide odor was found in several other areas.

The presence of high percentages of organic carbon and organic nitrogen is an indication of sludge deposits resulting from the discharge of municipal and industrial wastes, while sludges low in these organics may be considered inorganic, or "natural" deposits. The highest percentages of organic carbon (23.5) and organic nitrogen (1.29) associated with harbor sludges were found in the Fort Point Channel. This reach was intensively polluted and septic. Such values are similar to those associated with raw wastes from packinghouses, sewage or rapidly decomposing sludge. In samples from the remaining harbor stations, organic carbon varied from 0.4 to 5.5 percent, and organic nitrogen varied from 0.04 to 0.41 percent.

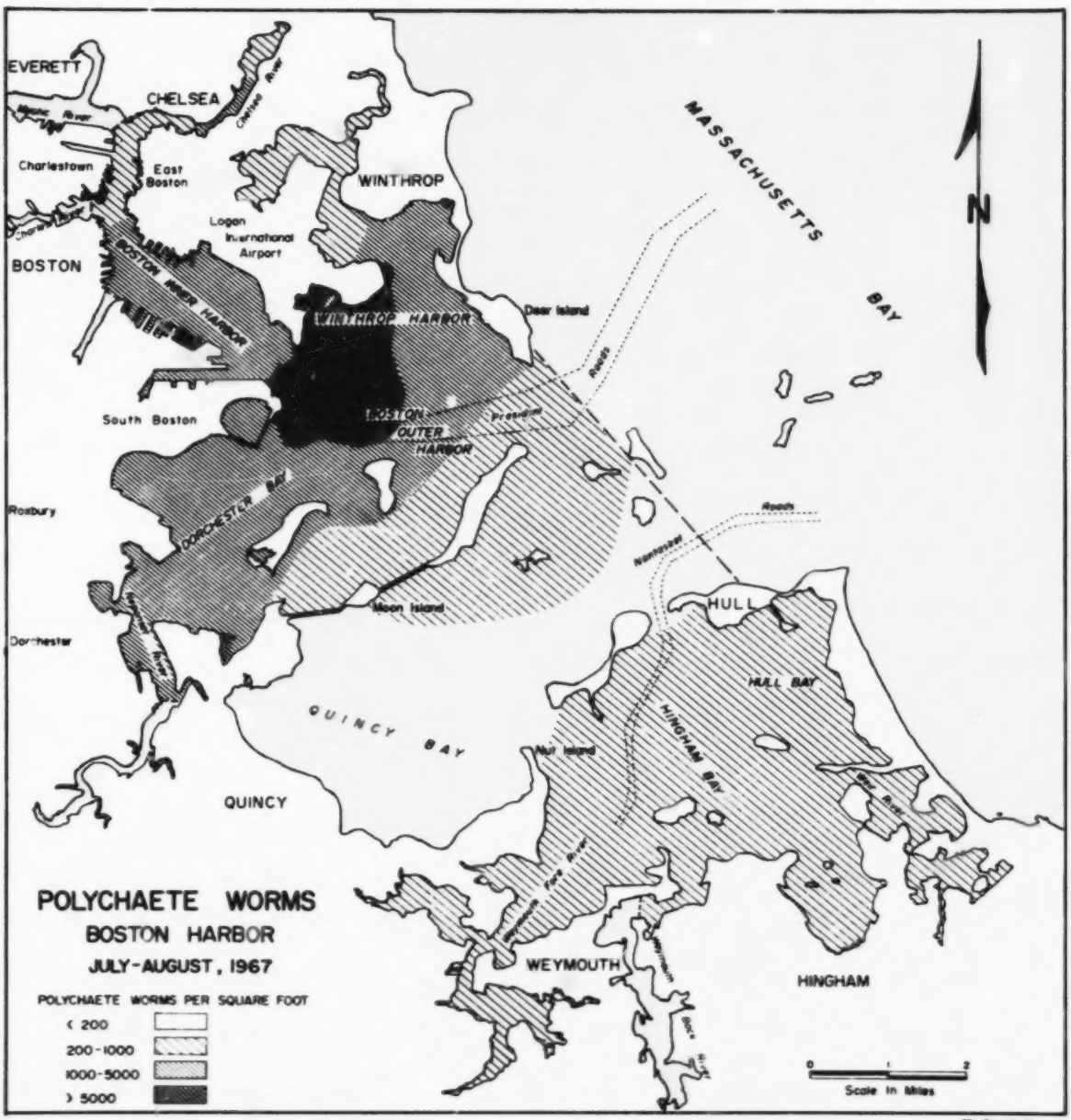

EVERETT
CHELSEA
Mystic River
Chelsea River
Charlestown
East Boston
WINTHROP
Logan International Airport
BOSTON
Charles River
BOSTON INNER HARBOR
WINTHROP HARBOR
Deer Island
Roads
MASSACHUSETTS BAY
N
South Boston
BOSTON OUTER HARBOR
President
Roxbury
DORCHESTER BAY
Nantasket
Roads
Moon Island
HULL
Dorchester
Neponset River
HULL BAY
QUINCY BAY
Nut Island
HINGHAM BAY
QUINCY
Weymouth Fore River
WEYMOUTH
HINGHAM
Weymouth Back River
0 1 2
Scale in Miles
POLYCHAETE WORMS
BOSTON HARBOR
JULY-AUGUST, 1967
POLYCHAETE WORMS PER SQUARE FOOT
< 200
200-1000
1000-5000
> 5000

FIGURE 7

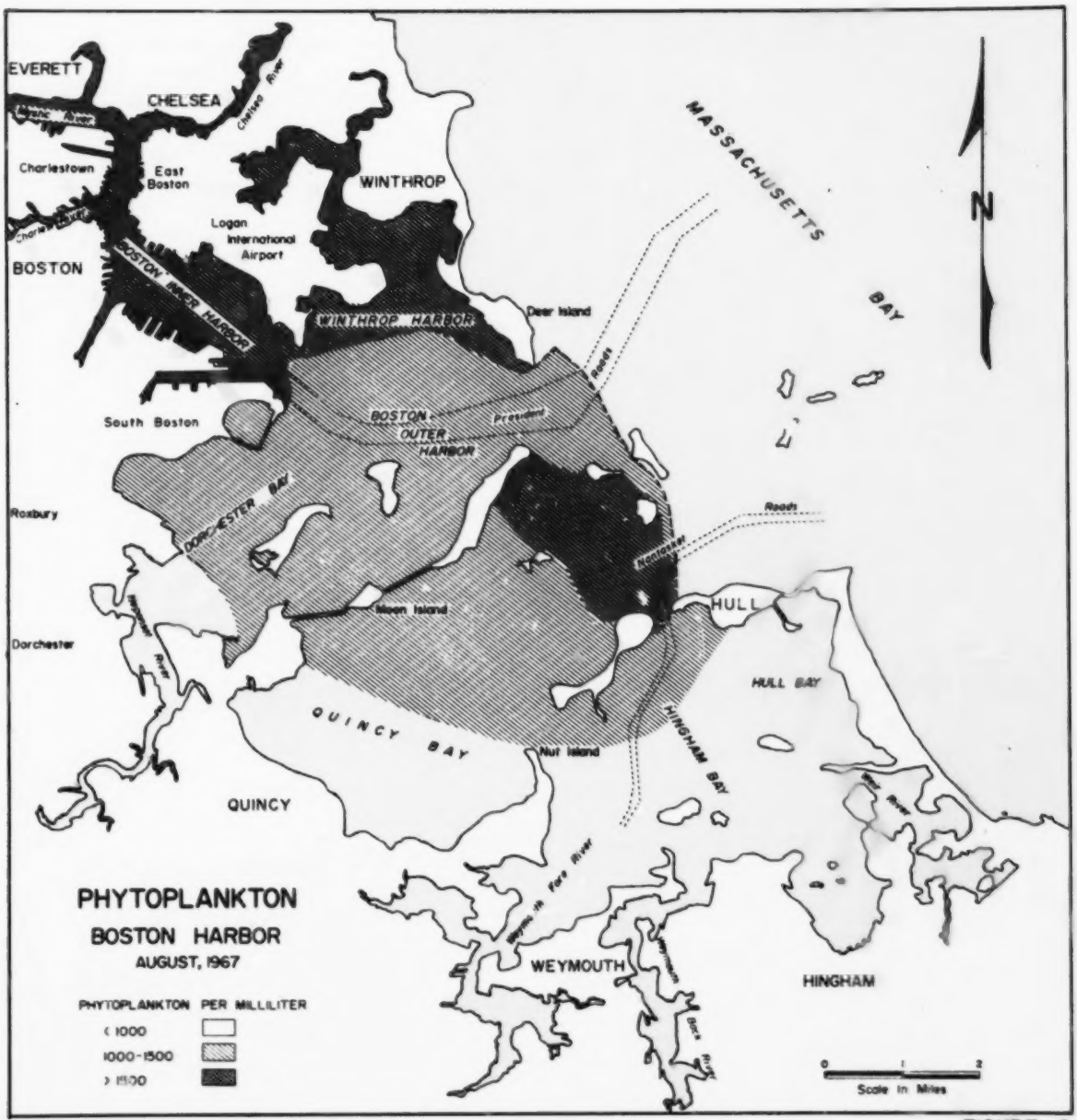

EVERETT
CHELSEA
Chelsea River
Charlestown
East Boston
WINTHROP
Logan International Airport
BOSTON
Charles River
BOSTON INNER HARBOR
WINTHROP HARBOR
Deer Island
Roads
MASSACHUSETTS BAY
N
South Boston
BOSTON OUTER HARBOR
President
Roxbury
DORCHESTER BAY
Nantasket Roads
Moon Island
HULL
Dorchester
Neponset River
HULL BAY
QUINCY BAY
Nut Island
HINGHAM BAY
QUINCY
Weir River
Weymouth Fore River
WEYMOUTH
Weymouth Back River
HINGHAM
PHYTOPLANKTON
BOSTON HARBOR
AUGUST, 1967
PHYTOPLANKTON PER MILLILITER
< 1000
1000-1500
> 1500
0 1 2
Scale in Miles

FIGURE 8

SURFACE WATERS

Sewage-like solids, other assorted rejectamenta, and oily slicks also were observed in the surface waters of most portions of Boston Harbor. Such materials were abundant near the Deer Island sewer outfalls at the mouth of Boston Harbor, near Moon Island, the north end of Long Island and the inland reach of Quincy Bay.

POLLUTION CONTROL AGENCIES

Several Federal, State and local agencies, departments and organizations are presently involved in developing or implementing actions relating to the water quality of Boston Harbor. The primary State and Federal agencies and their responsibilities are briefly outlined below.

STATE AGENCIES

Metropolitan District Commission. The Metropolitan District Commission (MDC) is a regional organization, created by the Legislature, serving the Metropolitan Boston area. Through the several divisions of the MDC, the metropolitan area is served with roads, water, sewerage, parks and recreation facilities.

The Sewerage Division maintains and operates two collection systems which eventually discharge to Boston Harbor. This system serves forty-two towns or 1.5 million people. A primary sewage treatment plant at Nut Island provides primary treatment for the south sewerage system. At Deer Island a primary plant is under construction to serve the north sewerage system.

Metropolitan Area Planning Council. The Metropolitan Area Planning Council, Department of Commerce and Development, was created by the Legislature to serve as a planning agency for the 110 communities in the Metropolitan Boston area. A comprehensive plan is being developed that will include land use and sewerage, water and transportation needs.

Division of Water Pollution Control. The Division of Water Pollution Control, Department of Natural Resources, is under the direction of the Water Resources Commission. This division, which was established in September of 1966 and has primary pollution control authority over all surface waters of the Commonwealth, is directed "to enhance the quality and value of water resources and to establish a program for the prevention, control and abatement of water pollution." Under this authority, the division sets, implements and enforces water quality standards and is charged with carrying out a comprehensive plan of water pollution control.

In compliance with the Federal Water Quality Act of 1965, the Division of Water Pollution Control submitted water quality standards to the Secretary of the Interior on June 20, 1967. After review by the Department of the Interior, these standards were approved on August 10, 1967. A copy of the portion of the standards that pertains to Boston Harbor is presented in pages 8, 9 and 10.

Division of Waterways. The Division of Waterways, Department of Public Works, has been given charge of the lands, flats, shores and rights in tidal waters of the Commonwealth. This division is empowered with the general care and supervision of the harbors and tide waters. Supervisory powers are exercised over the transportation and dumping of all materials dredged from tide waters and any other material to be disposed of in these waters. The division supervises the dock-side

loading of such barges and the ultimate disposal operation; however, inspectors from the Department of Natural Resources observe the transportation of these and other materials to the burning site.

Control of any building projecting into the harbor, the filling of tidelands, and the abandonment and removal of wrecks, hulks and shore structures is vested in the Department of Public Works.

State legislation provides for a five hundred dollar fine to be levied against anyone found guilty of discharging such an amount of crude petroleum or any other oils or bilge water into the waters or onto the tidal flats of the Commonwealth that it causes pollution or contamination.

Department of Public Health. The Department of Public Health is responsible for the health aspects related to water pollution. This department takes regulatory action against polluted bathing and shellfishing areas in order to maintain the public health, while the Division of Water Pollution Control is responsible for the investigation and the abatement of the pollution. To perform its role, the Department of Public Health carries out a water sampling program at the various beaches and shellfish beds in the harbor.

FEDERAL AGENCIES

Federal Water Pollution Control Administration. The Federal Water Pollution Control Administration (FWPCA), U.S. Department of the Interior, has the primary federal responsibility for pollution control as provided

by the Federal Water Pollution Control Act, as amended. Programs are maintained in the areas of sewage treatment plant construction grants, enforcement, water quality standards, comprehensive programs, research and other studies and grants. Since the beginning of the aid program, the Federal Government has furnished $3.8 million to help build thirty-eight projects, costing a total of $16.6 million in the Boston Harbor area (Appendix B).

The Oil Pollution Act of 1924 is administered by the Secretary of the Interior. This responsibility has been delegated to the FWPCA.

U.S. Army Corps of Engineers. The Army Corps of Engineers, U.S. Department of Defense, under the Rivers and Harbors Act of 1899, has jurisdiction over the discharge or deposit into navigable waters of any refuse matter other than that flowing in a liquid state from streets and sewers. This jurisdiction has been exercised primarily in the interests of navigation. In addition, the Secretary of the Army has control over any structure extending into, onto or over the navigable waters of the United States.

U.S. Coast Guard. The Coast Guard, U.S. Department of Transportation, cooperates with the Department of the Interior in handling oil discharges in navigable waters and cooperates with the Army Corps of Engineers in carrying out the Rivers and Harbors Act of 1899 in cases involving interferences with navigation.

U.S. Public Health Service. The Public Health Service (PHS), U.S. Department of Health, Education and Welfare, is consulted by the FWPCA

on all pollution problems affecting health over which the Public Health Service has administrative responsibility, such as shellfish growing areas, as required by the Water Quality Act of 1965. The PHS can exert pressure in shellfish sanitation through a cooperative agreement. Under the terms of this agreement, no State will accept shellfish from another State unless the shipper has a PHS approved shipper's number and the state shellfish sanitation program is endorsed by the PHS.

OTHER AGENCIES

New England River Basins Commission. The New England River Basins Commission has been established under the provisions of the Water Resources Planning Act of 1965 and is designated "...to serve as the principal agency for coordination of Federal, State, interstate, local and nongovernmental plans for the development of water and related land resources in its area..." The commission program is currently in the process of formulation.

New England Regional Commission. The New England Regional Commission was established under the Public Works and Economic Development Act of 1965 and is composed of the governors of the six New England States and a Federal co-chairman. A comprehensive economic plan with emphasis on promoting recreation, tourism and foreign trade and on the impact of water and air pollution is being developed.

APPENDICES

Appendix A. National Shellfish Sanitation Program, Growing Area Survey and Classification

Appendix B. Construction Grant Projects, Boston Harbor

APPENDIX A

Section C

GROWING AREA SURVEY AND CLASSIFICATION

1. Sanitary Surveys of Growing Areas.—A sanitary survey shall be made of each growing area prior to its approval by the State as a source of market shellfish or of shellfish to be used in a controlled purification or relaying operation. The sanitary quality of each area shall be reappraised at least biennially and, if necessary, a resurvey made. Ordinarily, resurveys will be much less comprehensive than the original survey since it will only be necessary to bring the original information up to date. Records of all original surveys and resurveys of growing areas shall be maintained by the State shellfish control agency, and shall be made available to Public Health Service review officers upon request.

Satisfactory compliance.—This item will be satisfied when—

a. A sanitary survey has been made of each growing area in the State prior to initial approval of interstate shipments of shellfish from that area. A comprehensive sanitary survey shall include an evaluation of all sources of actual or potential pollution on the estuary and its tributaries, and the distance of such sources from the growing areas; effectiveness and reliability of sewage treatment works; the presence of industrial wastes, pesticides, or radionuclides which would cause a public-health hazard to the consumer of the shellfish; and the effect of wind, stream flow, and tidal currents in distributing polluting materials over the growing area.[2] The thoroughness with which each element must be investigated varies greatly and will be determined by the specific conditions in each growing area.

b. The factors influencing the sanitary quality of each approved shellfish growing area are reappraised at least biennially.[3] A complete resurvey should be made of each growing area in an approved category at least once every ten years; however, data from original surveys can be used when it is clear that such information is still valid.

c. A file which contains all pertinent sanitary survey information, including the dates and results of preceding sanitary surveys is maintained by the State shellfish control agency for each classified shellfish area.

d. The State agency having primary responsibility for this element of the national program develops a system for identification of growing areas.

Public-health explanation.—The positive relationship between sewage pollution of shellfish growing areas and enteric disease has been demonstrated many times (*13*) (*14*) (*15*) (*16*) (*17*) (*18*) (*63*) (*64*) (*65*). However, epidemiological investigations of shellfish-caused disease outbreaks have never established a direct numerical correlation between the bacteriological quality of water and the degree of hazard to health. Investigations made from 1914 to 1925 by the States and the Public Health Service—a period when disease outbreaks attributable to shellfish were more prevalent—indicated that typhoid fever or other enteric disease would not ordinarily be attributed to shellfish harvested from water in which not more than 50 percent of the 1 cc. portions of water examined were positive for coliforms,[4] *provided the areas were not subject to direct contamination with small amounts of fresh sewage which would not ordinarily be revealed by the bacteriological examination.*

Following the oyster-borne typhoid outbreak during the winter of 1924–25 in the United States (*19*) the national shellfish certification program was initiated by the States, the Public Health Service, and the shellfish industry (*9*). Water quality criteria were then stated as:

a. The area is sufficiently removed from major sources of pollution so that the shellfish would not be subjected to fecal contamination in quantities which might be dangerous to the public health.

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[2] In making the sanitary survey consideration should be given to the hydrographic and geographic characteristics of the estuary, the bacteriological quality of the growing area water and bottom sediments, and the presence and location of small sources of pollution (including boats) which might contribute fresh sewage to the area.

[3] The purpose of this reappraisal is to determine if there have been changes in stream flow, sewage treatment, populations, or other similar factors which might result in a change in the sanitary quality of the growing area. The amount of field work associated with such a reappraisal will depend upon the area under consideration and the magnitude of the changes which have taken place.

[4] An MPN of approximately 70 per 100 ml.

b. The area is free from pollution by even small quantities of fresh sewage. The report emphasized that bacteriological examination does not in itself, offer conclusive proof of the sanitary quality of an area.

c. Bacteriological examination does not ordinarily show the presence of the coli-aerogenes group of bacteria in 1 cc. dilutions of growing area water.

The reliability of this three part standard for evaluating the safety of shellfish-producing areas is evidenced by the fact that no major outbreaks of typhoid fever or other enteric disease have been attributed to shellfish harvested from waters meeting the criteria since they were adopted in the United States in 1925. Similar water quality criteria have been in use in Canada with like results. The available epidemiological and laboratory evidence gives little idea as to the margin of safety, but it is probably considerable as indicated by the virtual absence of reported shellfish caused enteric disease over a comparatively long period of time (*18*) (*20*) (*21*) (*65*) (*69*) from waters meeting this criteria.

The purpose of the sanitary survey is to identify and evaluate those factors influencing the sanitary quality of a growing area and which may include sources of pollution, potential or actual; the volume of dilution water; the effects of currents, winds and tides in disseminating pollution over the growing areas; the bacterial quality of water and bottom sediments; die out of polluting bacteria in the tributaries and the estuary; bottom configuration; and salinity and turbidity of the water. Sources of pollution include municipal sewage discharged into the estuary or inflowing rivers; sewage brought into the estuary by tides or currents; surface runoff from polluted areas; industrial wastes; and discharges from pleasure craft, fishing boats, naval vessels, and merchant shipping.

Bacteriological examination of the growing waters is an important component of the sanitary survey. In many instances the bacteriological and related salinity data will also provide valuable information on the hydrographic characteristics of an area.[5] [6]

Ideally, a large number of water samples for bacteriological examination should be collected at each station. However, in most instances this is not practical because of time and budget limitations, and accordingly only a limited number of samples can be collected. Therefore, sampling stations should be chosen which will provide a maximum of data, and which will be respresentative of the bacteriological quality of water in as wide an area as possible. Sample collection should be timed to represent the most unfavorable hydrographic and pollution conditions since shellfish respond rapidly to an increase in the number of bacteria or viruses in their environment (*27*), (*36*) (*70*) (*71*) (*72*) (*78*).

There is no specified minimum number of sampling stations, frequency of sampling, or total number of samples. Sampling results obtained over a period of several years can be used as a block of data provided at least 15 samples have been collected from each of a representative number of stations along the line separating approved from restricted growing areas and there have been no adverse changes in hydrographic or sanitary conditions. Only occasional bacteriological samples are necessary from areas which are shown to be free from pollution.

Experience with the shellfish certification program indicates a tendency to omit or de emphasize some components of the sanitary survey unless a central State file of all shellfish sanitary surveys, reappraisals, and resurveys is maintained. This is particularly true where responsibility for shellfish sanitation is divided between two or more State agencies. Maintenance of a central State file for all shellfish sanitary survey information will also simplify the endorsement appraisal of State programs by the Public Health Service and will help prevent

[5] Bacteria in an unfavorable environment die out in such a way that following an initial lag period there is a large percentage decline during the first few days. Descriptions of studies on bacteria dieout have been published by Greenberg (*22*) and Pearson (*55*). Dieoff has also been investigated by the Public Health Service Shellfish Sanitation Laboratory at Woods Hole, Mass., and Pensacola, Fla. Application of this principle may be helpful in predicting the quantity of pollution which will reach an area and in establishing objective effluent quality criteria (*54*).

[6] In connection with the evaluation of sampling results, it should be noted that the MPN determination is not a precise measure of the concentration of bacteria (*4*). Thus, in repeated sampling from waters having a uniform density of bacteria varying MPN estimates will be obtained. The use of the tolerance factor 3.3 (applicable only to 5 tube decimal dilution MPN's) is one method of recognizing this variation. For example, in a body of water in which the median concentration of coliform bacteria is 70 per 100 ml., 95% of observed MPN's will be between 20 and 230 per 100 ml.; i.e., $70/3.3 = 21$ and $70 \times 3.3 = 230$

loss of old data which may be useful in evaluating the sanitary quality of an area.

Periodic reappraisals of the sanitary quality of shellfish producing areas are necessary to determine that environmental conditions are such that the original conclusions are still valid. A *resurvey* should be made within 1 year if the *reappraisal* shows a significant detrimental change.

2. Classification of Growing Areas.—All actual and potential growing waters shall be classified as to their public health suitability for the harvesting of market shellfish. Classification criteria are described in sections C–3, C–4, C–5, C–6, and C–7 of this manual. Except in emergency any upward revision of an area classification shall be preceded by a sanitary survey, resurvey, or reappraisal. A written analysis of the data justifying the reclassification shall be made a part of the area file.

Satisfactory compliance.—This item will be satisfied when—

a. All actual and potential growing waters in the State are correctly designated with one of the following classifications on the basis of sanitary survey information: *Approved; conditionally approved; restricted;* or *prohibited.*[7] [8]

b. Area classifications are revised whenever warranted by survey data.

c. Classifications are not revised upward without at least a file review, and there is a written record of such review in the area file maintained by the State shellfish control agency.

d. All actual and potential growing areas which have not been subjected to sanitary surveys shall be automatically classified as *prohibited.*

Public-health explanation.—The probable presence or absence of pathogenic organisms in shellfish waters is of the greatest importance in deciding how shellfish obtained from an area may be used. All actual and potential growing waters should thus be classified according to the information developed in the sanitary survey. Classification should not be revised upward without careful consideration of available data. Areas should be reclassified whenever warranted by existing data. A written justification for the reclassification simplifies Public Health Service appraisal of State programs.

A hypothetical use of the four recognized area classifications is shown in figure 1. This idealized situation depicts an estuary receiving sewage from two cities, "A" and "B." City "A" has complete sewage treatment including chlorination of effluent. City "B" has no sewage treatment. The estuary has been divided into five areas, designated by roman numerals, on the basis of sanitary survey information:

Approved

Area I. The sanitary survey indicates that sewage from cities "A" and "B" (even with the "A" sewage plant not functioning) would not reach this area in such concentration as to constitute a public-health hazard. The median coliform MPN of the water is less than 70/100 ml. The sanitary quality of the area is independent of sewage treatment at city "A."

Conditionally Approved

Area II. This area is of the same sanitary quality as area I; however, the quality varies with the effectiveness of sewage treatment at city "A." This area would probably be classified *prohibited* if city "A" had not provided sewage treatment.

Restricted

Area III. Sewage from "B" reaches this area, and the median coliform MPN of water is between 70 and 700 per 100 ml. Shellfish may be used only under specified conditions.

Prohibited

Area IV. Direct harvesting from this area is prohibited because of raw sewage from "B." The median coliform MPN of water may exceed 700/100 ml.

Area V. Direct harvesting from this area is prohibited because of possible failure of the sewage treatment plant. Closure is based on need for a safety factor rather than coliform content of water or amount of dilution water.

[7] Closures may also be based on presence of Marine Toxins or other toxic materials.

[8] States may use other terminology in describing area classifications; provided, that the classification terms used are consistent with the intent and meaning of the words "approved", "conditionally approved", "restricted", or "prohibited".

3. Approved Areas.—Growing areas may be designated as *approved* when: (*a*) the sanitary survey indicates that pathogenic microorganisms, radionuclides, and/or harmful industrial wastes do not reach the area in dangerous concentration, and (*b*) this is verified by laboratory findings whenever the sanitary survey indicates the need. Shellfish may be taken from such areas for direct marketing.

Satisfactory compliance.—This item will be satisfied when the three following criteria are met:

a. The area is not so contaminated with fecal material that consumption of the shellfish might be hazardous, and

b. The area is not so contaminated with radionuclides or industrial wastes that consumption of the shellfish might be hazardous (see section C, item 7, regarding toxins in shellfish growing areas), and

c. The coliform median MPN of the water does not exceed 70 per 100 ml., and not more than 10 percent of the samples ordinarily exceed an MPN of 230 per 100 ml. for a 5-tube decimal dilution test (or 330 per 100 ml., where the 3-tube decimal dilution test is used) in those portions of the area most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions. (Note: This concentration might be exceeded if less than 8 million cubic feet of a coliform-free dilution water are available for each population equivalent (*coliform*) of sewage reaching the area). The foregoing limits need not be applied if it can be shown by detailed study that the coliforms are not of direct fecal origin and do not indicate a public health hazard (*19*) (*20*).[7]

Public-health explanation.—A review of epidemiological investigations of disease outbreaks attributable to the consumption of raw shellfish reveals that two general situations prevail[8] insofar as pollution of growing or storage areas is concerned.

(1) Gross sewage contamination of a growing or wet storage area. (A report of a 1910 outbreak of typhoid fever involving 41 persons notes that raw sewage from a city with a population of 30,000 was discharged only a few hundred feet away from clam beds and floats (*27*) (*28*). In 1947 a case of typhoid fever was attributed to clams harvested 200 yards from the outlet of a municipal sewage treatment plant (*29*). In the latter case, the coliform MPN of the harbor water exceeded 12,000 per 100 ml. and the area had been posted as closed to shellfish harvesting.)

(2) Chance contamination of a growing or wet storage area by fresh fecal material which may not be diffused throughout the entire area (*14*) (*16*) (*17*) (*19*) and therefore not readily detectable by ordinary bacteriological procedures. The possibility of chance contamination was noted by Dr. Gurion in his report on a 1902 typhoid outbreak, and who is quoted in Public Health Bulletin No. 86, as "there is a zone of pollution established by the mere fact of the existence of a populated city upon the banks of a stream or tidal estuary which makes the laying down of oysters and clams in these waters a pernicious custom if persisted in, because it renders these articles of food dangerous at times, and always suspicious". The 1956 outbreak of infectious hepatitis in Sweden (691 cases) attributed to oysters which were contaminated in a wet storage area is an example of such contamination (*16*). Similarly in 1939, 87 cases of typhoid were attributed to fecal contamination of a storage area by a typhoid carrier (*14*).

It is well established that shellfish from water having a median coliform MPN not exceeding 70 per 100 ml.[8] *and which is also protected against chance contamination with fecal material*, will not be involved in the spread of disease which can be attributed to initial contamination of the shellfish. This is not surprising since a water MPN of 70/100 ml. is equivalent to a dilution ratio of about 8 million cubic feet of coliform-free water per day for the fecal material from each person contributing sewage to the area. This tremendous volume of water is available in shellfish growing areas through

[7] This MPN value is based on a typical ratio of coliforms to pathogens and would not be applicable to any situation in which an abnormally large number of pathogens might be present. Consideration must also be given to the possible presence of industrial or agricultural wastes in which there is an atypical coliform to pathogen ratio (*30*).

[8] There is a third general consideration in which shellfish may be contaminated through mishandling. This is not related to growing area sanitation and is considered in part II of this manual.

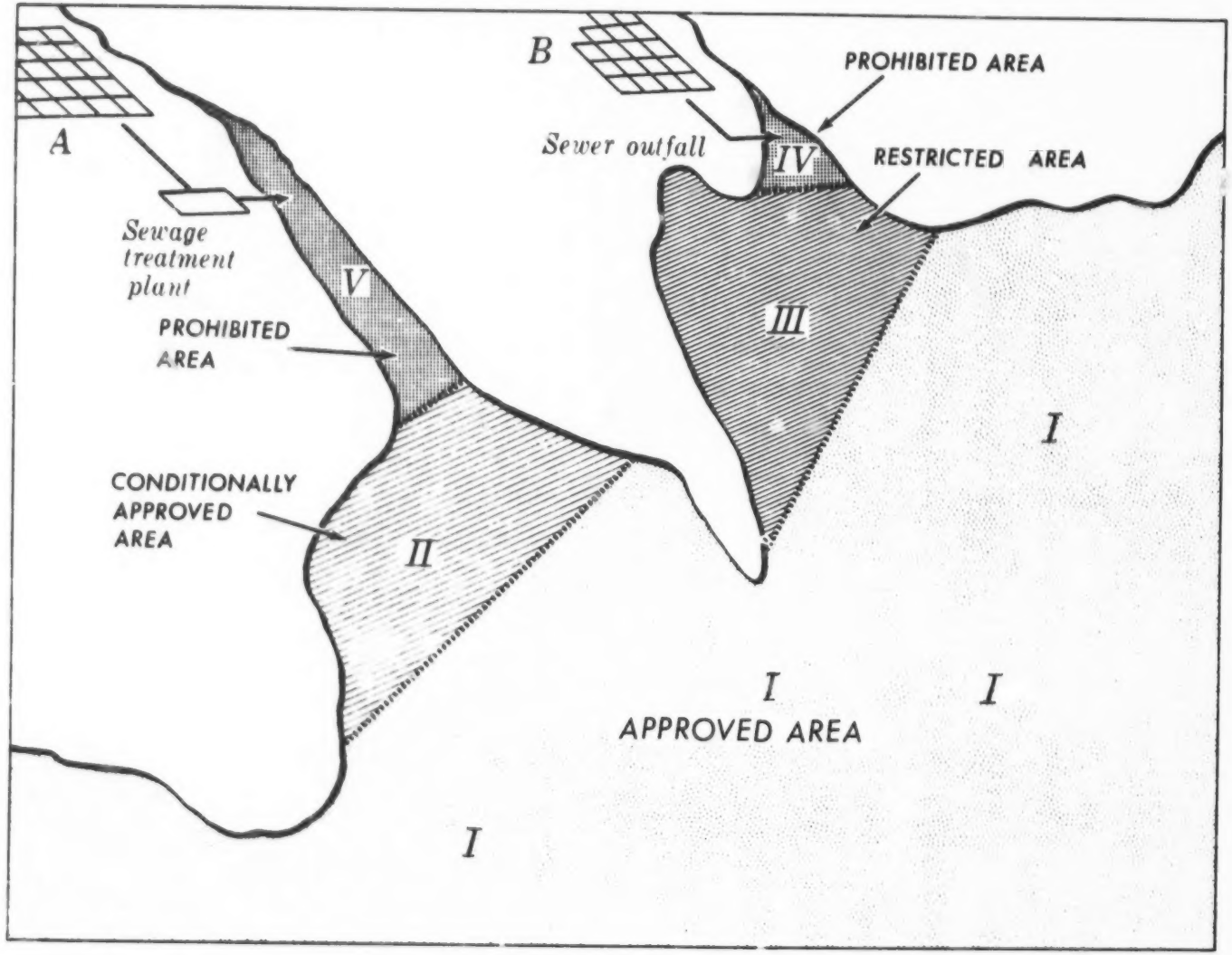
B
PROHIBITED AREA
A
Sewer outfall
IV
RESTRICTED AREA
Sewage
treatment
plant
V
III
PROHIBITED
AREA
I
CONDITIONALLY
APPROVED
AREA
II
I
I
APPROVED AREA
I

FIGURE 1

tidal action which is constantly bringing unpolluted water into the area.[8]

Areas which are approved for direct market harvesting of shellfish which will be eaten raw must necessarily meet one general test; i.e, sewage reaching the growing area must be so treated, diluted, or aged that it will be of negligible public-health significance. This implies an element of time and distance to permit the mixing of the sewage or fecal material with the very large volume of diluting water and for a major portion of the microorganisms to die out. Studies of the natural die-off of microorganisms in an unfavorable marine environment have been summarized by Greenberg (*22*).

The effectiveness of sewage treatment processes must be considered in evaluating the sanitary quality of a growing area since the bacterial and viral content of the effluent will be determined by the degree of treatment which is obtained (*2*) (*73*) (*74*) (*75*). The results of bacteriological sampling must also be correlated with sewage treatment plant operation, and evaluated in terms of the minimum treatment which can be expected with a realization of the possibility of malfunctioning, overloading, or poor operation.

The presence of radionuclides in growing area waters may also have public-health significance since shellfish, along with other marine organisms, have the ability to concentrate such materials (*31*) (*32*) (*33*) (*34*). The degree to which radioisotopes will be concentrated depends upon the species of shellfish and the specific radioisotope. For example, it has been reported that the Eastern oyster has a concentration factor of 17,000 for Zn^{65} whereas the concentration factor in soft tissues for Sr^{89} is approximately unity (*31*) (*33*). The distribution of the radioisotope in the shellfish and the biological half-life are also variable. Sources of radioactive materials include fall-out, industrial wastes, and nuclear reactors. Limiting maximum permissible concentrations of radioactive materials expressed in terms of specific radioisotopes and unidentified mixtures in water and food have been established (*35*) (*36*). The current standard should be consulted in evaluating the public-health significance of detected radioactivity in market shellfish.

See footnote 8 on page 13.

The bacterial quality of active shellfish will ordinarily be directly proportional to the bacterial quality of the water in which they grew; however, considerable variation in individual determinations may be expected. The coliform MPN's of the shellfish usually exceed those of the overlying water because shellfish filter large quantities of water to obtain food, thereby concentrating the suspended bacteria. This relationship will depend upon the shellfish species, water temperature, presence of certain chemicals, and varying capabilities of the individual animals.

4. Conditionally Approved Areas.—The suitability of some areas for harvesting shellfish for direct marketing is dependent upon the attainment of an established performance standard by sewage treatment works discharging effluent, directly or indirectly, to the area. In other cases the sanitary quality of an area may be effected by seasonal population, or sporadic use of a dock or harbor facility. Such areas may be classified as *conditionally approved*.

State shellfish control agencies shall establish *conditionally approved* areas only when satisfied that (a) all necessary measures have been taken to insure that performance standards will be met, and (b) that precautions have been taken to assure that shellfish will not be marketed from the areas subsequent to any failure to meet the performance standards and before the shellfish can purify themselves of polluting microorganisms.

Satisfactory compliance.—This item will be satisfied when—

a. The water quality requirements for an *approved* area are met at all times while the area is approved as a source of shellfish for direct marketing.

b. An operating procedure for *each conditionally approved* area is developed jointly by the State shellfish control agency, local agencies, including those responsible for operation of sewerage systems, and the local shellfish industry. The operating procedure should be based on an evaluation of each of the potential sources of pollution which may affect the area. The procedure should establish performance standards, specify necessary safety devices and measures, and define inspection and check procedures. (These procedures are described in

more detail in the following public-health explanation.)

c. A closed safety zone is established between the *conditionally approved* area and the source of pollution to give the State agency time to stop shellfish harvesting if performance standards are not met.

d. Boundaries of *conditionally approved* areas are so marked as to be readily identified by harvesters.

e. Critical sewerage system units are so designed, constructed, and maintained that the chances of failure to meet the established performance standards due to mechanical failure or overloading are minimized.

f. There is a complete understanding of the purpose of the *conditionally approved* classification by all parties concerned, including the shellfish industry. Successful functioning of the concept is dependent upon the wholehearted cooperation of all interested parties. If such cooperation is not assured the State should not approve the area for direct harvesting of market shellfish.

g. Any failure to meet the performance standards is immediately reported to the State shellfish control agency by telephone or messenger. In some instances States may find it desirable to delegate the authority for closing a *conditionally approved* area to a representative of the agency located in the immediate area.

h. The State immediately closes *conditionally approved* areas to shellfish harvesting following a report that the performance standards have not been met. The area shall remain closed until the performance standards can again be met plus a length of time sufficient for the shellfish to purify themselves so that they will not be a hazard to the public health. (See section D–1, "Relaying," for information on the length of time required for self-purification of shellfish.)

i. The State shellfish control agency makes at least two evaluations during the shellfish harvesting season of each *conditionally approved* area including inspection of each critical unit of the sewerage system to determine the general mechanical condition of the equipment, the accuracy of recording devices, and the accuracy of reporting by the operating agency.

j. It is discovered that failure to meet performance standards have not been reported by the operating agency, or if the performance standards are not met, the area will immediately revert to a *restricted* or *prohibited* classification.

k. All data relating to the operation of a *conditionally approved* area, including operation of sewerage systems, are maintained in a file by the State shellfish control agency.

Public-health explanation.—The *conditionally approved* classification is designed primarily to protect shellfish growing areas in which the water quality might undergo a significant adverse change within a short period of time.[10] The change might result from overloading or mechanical failure of a sewage treatment plant, or bypassing of sewage at a lift station.

Water quality in many growing areas in the more densely populated sections of the country is, to some degree, dependent upon the operation of sewage treatment plants. For example, the boundaries of an approved shellfish area might be determined during a period when a tributary sewage treatment plant is operating at a satisfactory level. If there is some interruption in treatment it follows that there will be some degradation in water quality in the growing area, which may justify a relocation of the boundaries. The degree of relocation would depend upon such items as the distance between the pollution source and the growing area, hydrography, the amount of dilution water, and the amount of pollution.

The concept is also applicable to other situations in which there may be a rapid or seasonal change in water quality. Examples of such situations include—

a. A growing area adjacent to a resort community. During the summer months the community might have a large population which might have an adverse effect on water quality. However, during the winter when there are few people in the community the water quality might improve sufficiently to allow approval of the area. In some States this is known as a seasonal closure.

b. A protected harbor in a sparsely settled area might provide anchorage for a fishing fleet

[10] A natural disaster may also cause many sewage treatment plants to be out of service for an extended period of time. The *conditionally approved* area concept is not ordinarily concerned with such emergency situations.

several months a year. When the fishing fleet is in, the harbor water would be of poor sanitary quality; however, during the remainder of the year the quality of the harbor water might be satisfactory. The area would be approved for shellfish harvesting only when the fishing fleet is not using the harbor.

c. The water quality in an area fluctuates with the discharge of a major river. During periods of high runoff the area is polluted because of decreased flow time in the river. However, during periods of low runoff the area might be of satisfactory quality and thus be approved for shellfish harvesting.

The establishment of *conditionally approved* areas might be considered whenever the potential for sewage contamination is such that the limiting water quality criteria for an *approved* area might be exceeded in less than one week due to a failure of sewage treatment, or other situations as described above.

The first step in determining whether an area should be placed in the *conditionally approved* classification is the evaluation of the potential sources of pollution in terms of their effect on water quality in the area. Potential sources of pollution include the following:

(1) Sewage treatment plants.

(*a*) Bypassing of all or part of sewage because of mechanical or power failure, hydraulic overloading, or treatment overloading.

(*b*) Reduced degree of treatment due to operational difficulties or inadequate plant.

(2) Sewage lift stations.

(*a*) Bypassing during periods of maximum flow due to inadequate capacity.

(*b*) Bypassing because of mechanical or power failure.

(3) Interceptor sewers or underwater outfalls.

(*a*) Exfiltration due to faulty construction.

(*b*) Leakage due to damage.

(4) Other sources of pollution.

(*a*) Sewage from merchant or naval vessels.

(*b*) Sewage from recreation use of area.

The second step in establishment of a *conditionally approved* area is the evaluation of each source of pollution in terms of the water quality standards to be maintained, and the formulation of performance standards for each installation having a significant effect on the sanitary quality of the area. Examples of performance standards might include:

(1) Bacteriological quality of effluent from sewage treatment plants. This might be stated in terms of chlorine residual if the bacteriological quality of the effluent can be positively related to chlorine residual. The following is an example of a performance standard (*37*): "The median coliform MPN, in any one month, shall not exceed 500 per 100 ml., based on not less than 16 composite samples per month, and not more than 10 percent of the samples shall have an MPN in excess of 10,000 per 100 ml. Determinations of the chlorine residual of the effluent should be made hourly and recorded in the permanent plant records."

(2) Total quantity of sewage which can be discharged from any given unit, or from a combination of units, without causing the basic water quality standards to be exceeded.

(3) Amount of shipping in the area and the amount of sewage which can be expected.

Design criteria which may be useful in formulating an opinion on the quantity of sewage which can be discharged into an area without exceeding the desired water quality standards include: Population equivalent (*coliform*) of sewage; predicted survival of coliform in sea water, effectiveness of chlorination, and the total quantity of clean dilution water in an area. Results of many studies on the survival of bacteria in sea water have been summarized in *An Investigation of the Efficacy of Submarine Outfall Disposal of Sewage and Sludge;* Publication No. 14, California State Water Pollution Control Board, 1956.

The mechanical equipment at critical sewage treatment or pumping units should be such that interruptions will be minimized. Wherever possible operations should be automatically recorded on charts. Examples of the requirements which might be imposed, depending upon the importance of the unit in terms of water quality, include:

(1) Ample capacity for storm flows. (Storm water should ordinarily be excluded from the sanitary system.)

(2) Standby equipment to insure that treatment or pumping will not be interrupted because of damage to a single unit or to power failure.

(3) Instrumentation of pumps and equipment to allow the regulatory agency to determine that performance standards have been met. Examples include:

(*a*) Recording scales to indicate rate of chlorine use. Chlorine flow can be integrated with hydraulic flow to establish a ratio.

(*b*) Liquid level recording gages in overflow channels of sewage treatment plants and wet wells of lift stations to indicate when overflow takes place. Charts should be dated and initialed by the operator. Gages should be calibrated so that discharge can be estimated.

(*c*) Automatic devices to warn of failure or malfunctioning at self-operated pumping stations or treatment plants.

(4) The effect of storm sewage can be calculated by multiplying the total estimated flow by the observed coliform content. The result can be expressed in terms of population equivalents (*coliform*).

Design and operation of equipment should be such that closure provisions should not have to be invoked more than once per year under ordinary circumstances.

A closed safety area should be interposed between the *conditionally approved* area and the source of pollution. The size of such area should be based on the total time it would take for the operating agency to detect a failure, notify the State shellfish control agency, and for the latter agency to stop shellfish harvesting. It is recommended that the area be of such size that the flow time through the safety area be at least twice that required for the notification process to become effective. Due consideration should be given to the possibility that closure actions might be necessary on holidays or at night.

The type of marking which will be required for *conditionally approved* areas will vary from State to State depending upon the legal requirements for closing an area.

The length of time a *conditionally approved* area should be closed following a temporary closure will depend upon several factors including the species of shellfish, water temperature, purification rates, presence of silt or other chemicals that might interfere with the physiological activity of the shellfish, and the degree of pollution of the area. (See section D–1 of this manual for additional information on the natural purification of shellfish.)

5. Restricted Areas.—An area may be classified as *restricted* when a sanitary survey indicates a limited degree of pollution which would make it unsafe to harvest the shellfish for direct marketing. Alternatively the States may classify such areas as prohibited. (See section C–6, this manual.) Shellfish from such areas may be marketed after purifying or relaying as provided for in section D.

Satisfactory compliance.—This item will be satisfied when the following water quality criteria are met in areas designated by States as *restricted*.[11] [12]

a. The area is so contaminated with fecal materials that direct consumption of the shellfish might be hazardous, and/or

b. The area is not so contaminated with radionuclides or industrial wastes that consumption of the shellfish might be hazardous, and/or

c. The coliform median MPN of the water does not exceed 700 per 100 ml. and not more than 10 percent of the samples exceed an MPN of 2,300 per 100 ml. in those portions of the areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions. (Note: this concentration might be exceeded if less than 800,000 cubic feet of a coliform-free dilution water are available for each population equivalent (*coliform*) of sewage reaching the area.)

d. Shellfish from *restricted* areas are not marketed without controlled purification or relaying.

Public health explanation.—In many instances it is difficult to draw a clear line of demarcation between polluted and nonpolluted areas. In such instances the State may, at its

[11] It is not mandatory that States use this classification. Areas not meeting the *approved* classification may be closed to all harvesting for direct marketing.

[12] Routine sanitary surveys and reappraisals of *restricted* areas shall be made on the same frequency as for *approved* areas. (See section C–1.)

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option, classify areas of intermediate sanitary quality as *restricted* and authorize the use of the shellfish for relaying, or controlled purification.

6. Prohibited Areas.—An area shall be classified *prohibited* if the sanitary survey indicates that dangerous numbers of pathogenic microorganisms might reach an area. The taking of shellfish from such areas for direct marketing shall be prohibited. Relaying or other salvage operations shall be carefully supervised to insure against polluted shellfish entering trade channels. Actual and potential growing areas which have not been subjected to sanitary surveys shall be automatically classified as *prohibited.*

Satisfactory compliance.—This item will be satisfied when:

a. An area is classified as *prohibited* if a sanitary survey indicates either of the following degrees of pollution:

(1) The area is contaminated with radionuclides or industrial wastes that consumption of the shellfish might be hazardous and/or

(2) The median coliform MPN of the water exceeds 700 per 100 ml. or more than 10 percent of the samples have a coliform MPN in excess of 2,300 per 100 ml. (Note: This concentration might be reached if less than 800,000 cubic feet of a coliform-free dilution water are available for each population equivalent (*coliform*) of sewage reaching the area.)

b. No market shellfish are taken from *prohibited* areas except by special permit as described in section D.

c. Coastal areas in which sanitary surveys have not been made shall be automatically classified as *prohibited.*

Public-health explanation.—The positive relationship between enteric disease and the eating of raw or partially cooked shellfish has been outlined in section C–1. Prevention of the interstate transport of shellfish containing sufficient numbers of pathogenic microorganisms to cause disease is a primary objective of the National Program. Therefore, areas containing dangerous concentrations of microorganisms of fecal origin, or areas which may be slightly contaminated with fresh fecal discharges, should not be approved as a source of shellfish for direct marketing.

7. Closure of Areas Due to Shellfish Toxins.—The State shellfish control agency shall regularly collect and assay representative samples of shellfish from growing areas where shellfish toxins are likely to occur. If the paralytic shellfish poison content reaches 80 micrograms per 100 grams of the edible portions of raw shellfish meat, the area shall be closed to the taking of the species of shellfish in which the poison has been found.[13] The harvesting of shellfish from such areas shall be controlled in accord with the recommendations of sections E–1 and E–2 of this manual.

The quarantine shall remain in effect until such time as the State shellfish control agency is convinced the poison content of the shellfish involved is below the quarantine level.[14]

Satisfactory compliance.—This item will be satisfied when—

a. The State shellfish control agency collects and assays representative samples of shellfish for the presence of toxins from each suspected growing area during the harvesting season. (See section B–2 for assay methods.)

b. A quarantine is imposed against the taking of shellfish when the concentration of paralytic shellfish poison equals or exceeds 80 micrograms per 100 grams of the edible portion of raw shellfish.

Public-health explanation.—In some areas paralytic poison is collected temporarily by bivalve shellfish from free-swimming, one-celled marine plants on which these shellfish feed. The plants flourish seasonally when water conditions are favorable.

Cases of paralytic poisoning, including several fatalities, resulting from poisonous shellfish have been reported from both the Atlantic and Pacific coasts. The minimum quantity of poison which will cause intoxication in a susceptible person is not known. Epidemiological investigations of paralytic shellfish poisoning in Canada have indicated 200 to 600 micrograms of poison will produce symptoms in susceptible

[13] This value is based on the results of epidemiological investigations of outbreaks of paralytic shellfish poison in Canada in 1954 and 1957 (38) (39).

[14] The provisions of this item apply only to shellfish which will be marketed as a fresh or frozen product as properly controlled heat processing will reduce the poison content of the shellfish.

persons and a death has been attributed to the ingestion of a probable 480 micrograms of poison. Investigations indicate that lesser amounts of the poison have no deleterious effects on humans. Growing areas should be closed at a lower toxicity level to provide an adequate margin of safety since in many instances toxicity levels will change rapidly (*38*) (*39*). It has also been shown that the heat treatment afforded in ordinary canning processes reduces the poison content of raw shellfish considerably.

A review of literature and research dealing with the source of the poison, the occurrence and distribution of poisonous shellfish, physiology and toxicology, characteristics of the poison, and prevention and control of poisoning has been prepared (*40*).

In Gulf coast areas, toxicity in shellfish has been associated (*12*) (*76*) with Red Tide outbreaks caused by mass bloomings of the toxic dinoflagellate, *Gymnodinium breve*. Toxic symptons in mice suggest a type of *ciguatera* fish poisoning rather than symptoms of paralytic shellfish poisoning.

APPENDIX B

APPENDIX B

BOSTON HARBOR

FEDERAL CONSTRUCTION GRANT PROJECTS

April 1968

Project Number	Name of Applicant	Status	Description	Type	Eligible Cost	WPC Grant
102	Bedford	3	7	1	$ 185,504	$ 55,650
48	Boston, City of	3	5	1	334,560	100,368
10	Boston, MDC	3	3	1	2,136,725	250,000
30	Boston, MDC	3	3	1	930,709	250,000
40	Boston, MDC	3	1	1	1,149,253	250,000
45	Boston, MDC	3	3	1	608,144	182,443
73	Boston, MDC	3	1	3	2,672,450	250,000
161	Boston, MDC	2	1	2	2,344,963	773,830
59	Braintree	3	3	2	17,973	5,391
100	Braintree	3	3	1	426,215	127,864
110	Braintree	3	3	2	115,404	34,621
136	Braintree	3	3	2	71,941	21,582
159	Braintree	3	3	1	141,000	46,530
124	Canton	3	3	2	212,607	63,782
68	Hingham	3	4	1	105,619	31,685
126	Hingham	3	4	2	43,706	13,110
158	Hingham	1	4	1	80,900	26,697
91	Lexington	3	3	1	484,189	145,256

Boston Harbor
Construction Grants Projects
(Continued)

Project Number	Name of Applicant	Status	Description	Type	Eligible Cost	WPC Grant
142	Lexington	1	4	2	$ 166,000	$ 49,800
151	Mass., Comm. of	2	7	1	456,800	137,000
134	Milford	3	7	7	267,000	80,000
139	Millis	2	1	2	215,000	64,500
83	Needham	3	4	2	44,048	13,214
65	Norwood	3	3	2	163,482	49,044
103	Norwood	3	3	1	35,835	10,750
32	Randolph	3	3	1	888,700	250,000
132	Randolph	3	3	2	29,097	8,729
52	Wakefield	3	3	1	153,267	45,980
63	Wakefield	3	3	2	57,777	17,333
107	Wakefield	3	3	2	130,000	39,000
133	Wakefield	3	3	2	86,376	25,912
51	Westwood	3	3	1	174,698	52,410
75	Westwood	3	3	1	230,424	69,127
49	Weymouth	3	3	1	219,844	65,953
121	Weymouth	3	3	2	187,727	56,318
36	Woburn	3	3	1	96,085	28,826
38	Woburn	3	3	1	54,115	16,234
153	Woburn	2	3	2	186,200	61,440
					$16,632,436	$3,770,379

APPENDIX B (Continued)

EXPLANATORY NOTES

PROJECT NUMBER

As assigned by State agency.

NAME OF APPLICANT

As listed in the project application for each state. In multi-municipal projects, participating communities are indented under main applicant.

STATUS

Status of projects is indicated as follows:

(1) Project approved (grant offer made)
(2) Project under construction
(3) Project completed

DESCRIPTION

Description of the project as outlined in project application:

(1) Treatment Plant
(2) Outfall Sewer
(3) Intercepting Sewer
(4) Other
(5) Treatment Plant, Outfall Sewer and Intercepting Sewer
(6) Treatment Plant and Outfall Sewer
(7) Treatment Plant and Intercepting Sewer
(8) Outfall Sewer and Intercepting Sewer
(9) Waste Stabilization Ponds and Appurtenances

TYPE

Type of construction as described in the application:

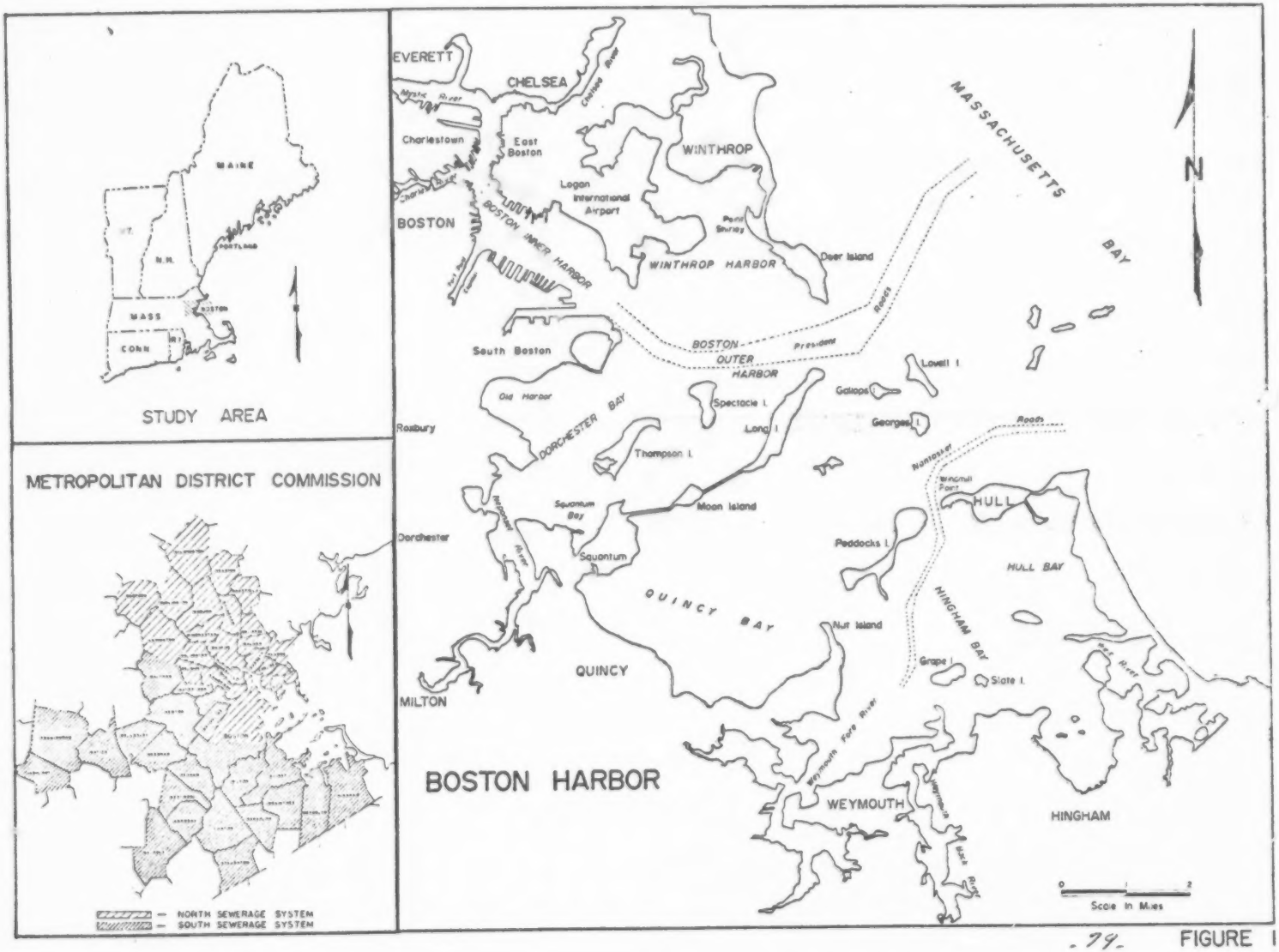
(1) New
(2) Extension or Addition
(3) Remodeling and Alteration
(4) New, Extension and Remodeling
(5) New and Extension
(6) New and Remodeling
(7) Extension and Remodeling

ELIGIBLE COST

Estimated project cost in which Federal grant funds are participating.

WPC GRANT

Amount of the Federal Water Pollution Control (WPC) grant(s) offered to the applicant.


STUDY AREA
METROPOLITAN DISTRICT COMMISSION
NORTH SEWERAGE SYSTEM
SOUTH SEWERAGE SYSTEM
BOSTON HARBOR
EVERETT
CHELSEA
Mystic River
Chelsea River
Charlestown
East Boston
WINTHROP
Logan International Airport
BOSTON
Charles River
BOSTON INNER HARBOR
WINTHROP HARBOR
Deer Island
Point Shirley
MASSACHUSETTS BAY
Roads
South Boston
BOSTON OUTER HARBOR
President
Lovell I.
Gallops
Old Harbor
Spectacle I.
Georges I.
Roxbury
DORCHESTER BAY
Long I.
Thompson I.
Nantasket
Roads
Bingham Point
HULL
Squantum Bay
Moon Island
Dorchester
Neponset River
Squantum
Peddocks I.
HULL BAY
QUINCY BAY
Nut Island
HINGHAM BAY
QUINCY
Grape I.
Slate I.
MILTON
Weymouth Fore River
WEYMOUTH
HINGHAM
Weir River
Monatiquot River
N
0
1
2
Scale in Miles

-79- FIGURE 1